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Individuality in Education[1]

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THERE are, I think, two important elements in individuality. First, is the distinctive difference, something that marks off one person from another. A noted philosopher, in emphasizing the principles of individuality, said that if one were to take all the leaves on all of the trees in the world, it would be impossible to find two leaves exactly alike. Two oaks or two maples might resemble each other, but there would be no duplicate. Certainly, as we go up the scale in existence, this element of diversity of distinction becomes more important. In the lower forms of life, for example, there is little difference of parts; the cells are all very much like each other. All jellyfish resemble each other. When we get to the height of the scale of life, to human beings, we find differences of parts, differences of form of structure, instead of similarity or close resemblance. One person is marked off from another; it is easy to tell them apart. However, this distinctiveness or difference, by itself would not give all that is really valuable in individuality. We may have two pennies and two nickels of different years and of different design, but we do not care about this difference,—one is just as good as the other. We do not care as long as one will buy as much as the other.

This additional principle of individuality means this: there is not merely difference or distinction, but something unique or irreplaceable in value, an unique difference of value. Human beings are not like the nickel or mechanical products which are as much like each other as peas in the pod. As long as we get peas enough we do not care which individual pea. They become substitutes for each other. When we get human individuals, we get the principle that each individual has some-

1 Address given at the State Conference of Normal School Instructors at Bridgewater, Mass., Sept. 5, 1922.

thing that is unique or irreplaceable. No one else will quite take his place in the world or do quite the same thing that he will do. I think that is what we mean by the idea of equality. We do not mean that people are physiologically or psychologically equal, but we do mean that every human being who is normal has something so distinctive that no other individual can be substituted for him.

The principle of individuality, then, is having a place and work in the world that no one else can quite do. This gives us a measure. The more mechanical, the more things are similar to each other; but as we rise to what is vital, rise in the sphere of life to what is spiritual, moral and intellectual, the principle of individuality counts for more and more. That is why the principle of individuality has such claims in education. It is the measure of whatever is elevating in the rank of life in spiritual, moral and intellectual beings.

The difficulties are practical rather than theoretical, when we come to the individual in education. On the theoretical side I think they come largely from a misapprehension of the meaning of individuality. The first misapprehension is that we often confuse individuality with "bumptiousness," or conceit, or self-assertion, or some kind of aggressiveness, instead of having something of distinctive worth or value to contribute to life. Real individuality is unconscious rather than conscious or self-conscious. Individuality is a particular way of feeling things, thinking things, and doing things, something which goes into, colors and dyes everything which a person has to do with.

Take, for example, two persons. Each uses the words, "I think." One emphasizes the "I." What he thinks may be very commonplace and may be what everyone else thinks is so; but because he emphasizes "*I* think,"—"I am the oracle; when I open my mouth let no dog bark." Another person says, "I *think* so and so." He may refer to something that is familiar and commonplace, but we will be struck by something distinctive, some peculiar form, something original in the particular expression about that very common thing. That illustrates what is meant by my saying that individuality is a certain way of doing things, thinking things, and feeling things, which runs through everything and gives it its peculiar color,

something which irradiates unconsciously whatever the person has to deal with.

The opposition to the theory and practice of the principles of individuality in education seems to me to be based in a large measure upon the supposition that the recognition means something of the nature of conscious assertion of individuality, conceit, a kind of "bumptiousness." It is quite possible that some teachers, under the guise of individuality, are really simply engaged in cultivating this "bumptiousness," that is, giving the pupil an exaggerated idea of his own importance as compared with that of other people. What we need, then, is to view this matter right; to get rid of the notion that connects individuality with the conscious idea of importance and associate it rather with the more subtle characteristics of individuality, which make the person distinctive and stamp his personality in a more or less unconscious way upon everything that the person has to do with.

The personality to be recognized means that each one of us has his own bias, his own preferences, his own instinctive tendency to prefer, not only things, but also ways of doing things. Our respect for individuality does not mean that the teacher shall single out the pupil and make him think his ideas are more important than others, but rather give opportunity to the pupils to give expression to their own special interests and their own special ways of approach, instead of trying to impose purely artificial beliefs and standards.

Take an instance which may be somewhat exaggerated, but which still is found in many schools. Children are given problems in arithmetic. The teacher believes there is one scientific and proper method of approaching these problems. One child does the problem in a way which diverges from the orthodox conventional method laid down by the text-book, the teacher, or the particular course of study. Instead of recognizing something valuable, something precious, something to be encouraged, the teacher frowns upon the pupil and insists on the adoption of a certain uniform method of arranging the result.

In less extreme cases than that, teachers are emphasizing the value of uniformity, tending to suppress this distinctive angle of approach on the part of the pupil. This emphasis on the uniformity of approach tends to get the better of the natural

individual way of dealing with the subject on the part of the pupil.

The grammar of old-fashioned teaching, the analysis of arithmetical problems, comes, from the standpoint of the children, to mean certain forms of words with changing figures. For example, a child in the third grade told his parents that they had in the third grade a new kind of multiplication from that of the second grade. The child said: "Last year we always said 'two times two is four cents,' and this year we say, 'two times two are four cents.'" Now this is extreme; but it illustrates the tendency to exaggerate or encourage uniformity, certain common forms of doing, instead of rightly assisting every individual to go at the matter in his own way.

I think that this is responsible for the disregard or even contempt in which many people outside of the teaching profession hold the whole matter of teaching or pedagogy. They have somehow come to associate every idea of pedagogy and every idea of method with a formulated, uniform way of doing things, while in actual life we realize that the individual should have his own way of doing things, throwing individuality into whatever he does.

Individuality really means a certain originality of method. Originality is not to be measured by newness or originality of product. Very few people can produce things really original in any important measure, but anyone can contribute something of originality to the way he goes at things.

Mr. Crothers tells of a gentleman of an exploring turn of mind who climbed a tree to view the landscape, and as he climbed he saw a body of water. Coming down, he proclaimed he had discovered the Pacific Ocean. It turned out to be nothing but a local and circumscribed pond. He had the disposition, and if the Pacific Ocean had only been there he *would* have discovered it, for his heart was in the right place. We are not going to discover Pacific Oceans; we are only going to discover ponds; but nevertheless, there is possible an element of originality on the part of teachers and pupils in the way of discovering ponds and even puddles.

Why is it that children are such a constant source of delight to most grown people? Certainly the parents and fond rela-

tives feel there is and never was anything like this baby. They somehow appreciate the uncommonness or originality of the small child, and feel that he has a certain element of original genius in him. Where does this all go to? Later on children become so much alike. Perhaps in earlier years it is because we recognize that the child is engaged in discovering a new world. He has to do it himself,—this discovering his own world,—and he cannot do it through anyone else's thoughts or feelings.

It is not a false belief that makes fond parents and relatives attribute originality to small children. There must be something wrong with the school and the home and the neighborhood if we allow this quality of originality to die out, and expect the individuals later on to be more or less copies of each other. It is a question if the school is not somehow or other responsible for the elimination of this individuality, because of the undue emphasis put on foreign matter, on strictly uniform methods of demonstration and instruction, on uniformity of subject matter, ground to be covered, and so on.

In the second place individuality is something that is internal and intellectual, rather than something which is external and physical. I have noticed, in the criticisms on ideas of freedom in the school, that it is generally assumed that individuality means a large amount of physical unrestraint: children "doing as they please"; something external and physical rather than internal and mental. There may be a great deal of "doing as a pupil pleases," absence of restraint, a great deal of physical activity, with very little display of individuality, with very little opportunity for individuality.

If you will notice a group of children under unusual circumstances, perhaps under some constraint, you will find that if one boy begins to "rough-house," others imitate him, and you get a scene of disorderliness. They are not displaying their individuality, but, on the contrary, they are imitating each other, for disorderliness is very largely imitation among children. The mere absence of physical restraint, or its presence, has practically nothing to do with the matter of individuality. Individuality is rather a distinctive way in which a person in his feelings and desires approaches any subject matter or any piece of work he has to do; that is, the way he puts himself

into it. This does not mean that the presence or absence of physical restraint has nothing to do with the matter. It does,—but it is not an end in iself.

Respect for individuality certainly means that the teacher should respect his or her own individuality. Sometimes teachers carry respect of pupil's individuality to a point where they lack respect for their own individuality.

There is need for more outward freedom than is permitted in many schools; much more than was permitted in the traditional school, with the emphasis upon quiet, upon silence, upon physical immobility. The question of the amount and degree of activity has something to do with this matter of real individuality, but it is a question of *means* and conditions, rather than ends. We need enough physical freedom and mobility so the students can express their mental individuality, but we do not need any more.

I think the laboratory gives a good example of what I mean. The individual has to be using his hands, doing things, but his experimenting in the laboratory is not simply running wild and at random. He has to have enough physical activity to see that his ideas are made definite and precise; that he is getting principles rather than taking information on faith at the word of the teacher or textbook.

We need, on the whole, more elbow-room for activity of the outer sort, more freedom and spontaneity of action in the schoolroom and on the playground than we usually get, not because that is the act of self-expression or end in itself, but because, with a certain degree of elbow-room we can get opportunity for the students to think for themselves, to work out their own plans, to formulate their own problems, to carry their ideas into execution, and to test their plans and ideas to determine how they work out.

That is one thing I meant, then, when I said that the difficulties are practical rather than theoretical. Real individuality is intellectual, inner, rather than physical. We talk about thinking for one's self. After all, the words "for one's self" are superfluous or redundant. It is not thought unless it is for one's self. To develop thinking we must have respect for the individual element, the distinctive element, which is un-

replaceable in the workings of the mind. Respect for individuality is in its essence respect for the mind and the workings of the mind; and the teacher who has respect and reverence for individuality has reverence for the human spirit and for whatever is characteristic in the work of the human spirit. He recognizes that that which marks off humanity from the physical is that in the physical sphere we can have uniformity, a unit can be standardized. We find here the difference between the factory and the school. The factory deals with dead things, inanimate things, where one piece can replace another. This condition makes for economy and efficiency. The spirit, or soul, or mind is the element that cannot be standardized in this mechanical way without doing damage to the mind and reducing it to a lower level.

There is a third misapprehension. It is that individuality means a sort of isolation; that it is unsocial rather than social. Now exactly the contrary is the case. Only in social groups does a person have a chance to develop individuality. On the other hand, the more you get identical similarity and repetition in a number of persons, the more you are eliminating both individuality and the social element. We would not think of holding up a prison as a model of community life, but it is there that individuals are reduced to units like others, known by numbers not by name, with the chain-gang and the lock-step, attempting to have everyone do the same thing at the same time. In the community life of the ideal sort, the family marked by the spirit of unity, the town, or the nation, the more you have of real social unity the more diversity, the more division of labor, and the more differentiation of operations there is.

I think we owe a great deal to Madame Montessori, but she has misled herself and others in assuring that there must be isolation or separation in order to get individuality; that each child must be doing something by himself rather than working with others; that it is impossible to combine the two principles of school work with the development of individuality. I think quite the opposite is the case. Children, of course, need a certain amount of isolation. They must get off by themselves and have time to think. This is true; but in the main, the best stimulus to the inventiveness and the ingenuity of the child,

the calling out of his own individuality, is found when the individual is working with others, where there is a common project, something of interest to them all, but where each has his own part. There may be classes where there is no unity. There may be classes where there is no social group. Here again our emphasis on the class as a unit has not only had a tendency to depress, if not eliminate respect for individuality in education, but has also tended to eliminate the social element in education.

There is a good deal of talk about socializing the recitation. The word recitation to most minds suggests a uniform rehearsal. All the pupils are asked questions on the same subject matter, and if all of them have learned their lesson they are able to say the same thing in about the same way. Now what is there social about that? As all have the same book, the only child who would learn anything is the one who has not done his duty. The others sit there more or less bored. The result is, of course, that the motive instead of being social is purely competitive. One child is measured against another. If we are going to socialize the recitation, pupils must have an opportunity for the assignment of different matter, and each be required to make his own contribution. A large part of the value of the library is that it affords an opportunity to socialize the recitation by diversifying assignments, providing for different phases of the subject matter, so that the recitation period, instead of being a uniform recital, gives different responsibilities, so that the recitation becomes a clearing-house, a place of exchange, an intellectual give and take, where each person has something to give and also something to receive from the special studies which others have made. Thus you socialize and also individualize the recitation, and eliminate mechanical uniformity from the recitation.

Suppose you meet someone from Mexico. He tells you what he has seen there, of his own experiences. You are interested. He communicates to you something of his personal interest in the place. Now you meet him again, one, two, three, four, five, six, seven times. Each time he tells you of the same experiences, and then asks you questions about what he has told you of Mexico. Wouldn't you lose interest in Mexico? Wouldn't

you dodge around the corner whenever you saw your friend coming?

How much of the children's aversion is thus caused? Is the mind really averse to learning? Isn't there an intellectual appetite for new books, new horizons, new outlooks? Haven't we imposed mechanical uniformity upon the minds of pupils, preventing them from displaying their own interests and preferences? Isn't that largely responsible for this acquired aversion to books and to study?

A mother was deploring the lack of interest of her boy in reading what she considered good classical literature. She said, "We never have suggested anything, but that he would reply, in an abrupt way, 'Oh, I have had that.'" His work in the university had not stimulated him to further reading, or to read literature of a different type. It was something he had been compelled to do, and had left him with an aversion to reading.

I think it would be possible to destroy a boy's interest in playing marbles and baseball by reducing it to prescribed exercises to be gone through in a regular way according to set instructions and at a certain time. The real reason why children are interested in play is not because of innate depravity, but because we have permitted the elements of individuality to remain in play, while we have unnecessarily eliminated them from what we call studies.

To go back to the point,—the problem of developing the individual is not a problem of isolating the child, is not giving something different to each, but rather in finding some community project in which each can take his own part, and in the carrying out of which each can make his own contribution.

It is like the life of the home, where the child is happier when he can do something with and for the parents than he is when shut off by himself and has no sense of participating in any undertaking in which others are engaged. The kind of individuality developed is that which is developed in some sort of social give and take, participating with one another. It is something where the different parts fit together, and the child knows that he, as an individual, contributes to what others are doing.

Now, my remarks, especially about the common apprehensions and confusions, if I may inject a personal element here, are largely a result of a somewhat prolonged experience. Trying to stand for freedom in dealing with teaching, I have found that I have been considered by many as upholding the doctrine "that children should do exactly as they please." Therefore, I was led to analyze more carefully what I really did believe, and I had to admit that I had set out without knowing what the real meaning of individuality was. I have tried to give you the net results of my thinking on this matter, to put the place and importance of individuality in a way which would inevitably avoid harmful apprehensions,—equally harmful whether accepted or rejected.

To sum up the points I have made: first, there is undue emphasis on the conscious acts. We are training the pupil to argue rather than to think. Second, there is undue emphasis on the external or more physical element of freedom of action. This latter is certainly important, but is a means and condition for developing the intellectual and moral element, rather than the end in itself. Third, there is an idea that to develop individuality means a sort of isolation or separation of one person from another, something opposed to the community spirit. Robinson Crusoe did not cease to be a social individual just because he was by himself on an island. He had his memories, his expectations, his experiences, which had come from his former association with other people.

You cannot define individuality physically or externally. It is a matter of spirit, of soul, of mind, and the way in which one enters into co-operative relations with others.

The Educational Value of Scientific Toys[1]

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Ever since Hero, of ancient Greece, built and played with his *toy* steam-engine, the world of science has kept pace with the world of toys. The manipulative and experimental instincts of man, in seeking outlets for activity have always produced, perhaps as mere by-products, devices and processes that were designed to amuse, to attract attention, to seize the fancy. But strangely enough, these little tricks of mechanical curiosity, these naive attempts to mystify one's fellow-man have had a strange way of stimulating someone toward serious utilization of one of nature's forces. Thus the magnet was once a plaything, till, in a sudden burst of development, it became one of the fundamentals of modern civilization. The air-pump, the prism, the lens, the camera-obscura, electrostatics, the telescope, the gyroscope, the telephone, and very recently, radio communication, have all "done their bit" on the vaudeville stage that science operates for the delectation of humanity.

If it but be remembered that young Isaac Newton and adolescent Faraday, as well as all the rest of galaxy of men who have brought science to its present state, developed their love, interest, yes, and their fundamental background and experience, in play with science toys, it will not be difficult for us as teachers to pay more attention to this play activity with science that goes on amongst our boys and girls when they are outside of our classroom.

A scientist at work is in a very real sense a scientist at play. That is what our modern educational theorists mean when they speak of the identity of play and work; of motivation; of the utilization of the inherent instincts and interests of the child; and of the project method. That concept also explains the recent tendency on the part of educators to study carefully the after-school or extra-curriculum activities of our boys and girls. School may begin at nine and end at three; but it is very pos-

1 Paper read before joint meeting of Physics, Chemistry, and General Science Teachers Associations of New England, Dec. 3, 1921, and before meeting of New Jersey State Science Teachers Association, May 13, 1922.

sible, and frequently too probable, that a boy's or girl's *real* education begins at school dismissal.

It is my purpose to present in this paper a brief description of a study which has been made of the different materials and activities which engage a good part of the attention of the junior high school boy, especially in his after-school time. These materials and activities are unique; because they offer the city boy, cooped up in an apartment house, the same outlet for his mechanical instincts and curiosities as the farm provides for the country boy.

Go to the toy department of the average department store, or to the annual toy-fair held by the Toy Manufacturers' Association, and you will note that there are two major types of toys. The first makes it appeal to the primal sensations of color and motion. The second might be termed, "toys with a meaning." In the last five years there has been a steady and rapid growth of this latter class of toy. There are four different groups of these Sets or Outfits, as they are called: Mechanical, Electrical, Chemical, and Sets for Special Purposes.

Of the mechanical sets, two are worthy of mention: the Meccano and the Erector. In the electrical field we have the St. John Outfits, the Gilbert Outfits, the Electro-Importing Outfit, and the Meccano Electrified. In the chemical field we have the Chemcraft and the Chemistry Outfit. And in the last category we have outfits such as Experiments with Magnetism, Experiments with Light, Experiments with Heat, Experiments with Sound, and Experiments with Air and Water; the Weather Bureau Outfit, the Mineralogy Set, the Radio Set, the Surveying Set, the Microscope and Telescope Set, and so on.

Each set comes in a box, neatly and attractively arranged, and contains a manual describing how to perform hundreds of experiments (with reasons and principles in full), together with all the necessary equipment for performing these experiments. The average price is about four dollars, and in many cases a boy can buy a one-dollar set and little by little buy the extra parts, which will turn his set into a four-dollar or even ten-dollar set.

The history of the development of Meccano is typical of a great many of these outfits, and is significant educationally. The inventor is Frank Hornby of England. Born at a time

when the possibilities of scientific inventions were beginning to grip the minds of men, he spent his youth and early manhood in dreaming of inventions and mechanical contrivances to do new and wonderful things. Practically all of his efforts in that direction were complete failures, but he carried with him into manhood an appreciation for this great longing of the normal boy to manipulate, to experiment, to "make things go"; so that when his own two boys arrived, it was with keen understanding that he undertook to satisfy their craving to do things.

The derrick has always proved a particularly fascinating object for boys. Hornby conceived the idea of constructing a derrick that would actually lift things, and which could be dismantled and its parts used for other purposes when the boys got tired of the derrick. The first project worked out to the satisfaction of his two boys; it was but a simple step to build with the same parts other objects of interest. Gradually the parts were standardized and perfected so as to be as interchangeable as possible. The ingenuity of his boys and his own ability to play as a boy, soon developed an imposing array of different models,—all built out of strips of steel, accurately and uniformly perforated, fastened by miniature brass nuts and bolts, and operated by real gears, belts and pulleys.

Dr. Hele-Shaw, professor of engineering at University College, Liverpool, recognized the educational value of Hornby's toy and assisted the latter in launching the venture commercially. A good many of the original investors in the scheme were men and women who were inspired by the Froebel doctrine and the writings of Horace Mann, and who believed with Herbert Spencer that "Invariably children show a strong tendency to make, to build; a propensity which, if duly directed, will not only prepare the way for scientific conceptions, but will develop these powers of manipulation in which most people are so deficient."

Thus it is important to note that Meccano had its origin in educational ideals. But, as with hundreds of other attempts to make money out of education, there soon arose difficulties. Hornby's toy was sold under the title, "Hornby's System of Mechanical Demonstration," in which he endeavored to provide "an economical and yet very effective series of apparatus for

demonstrating the main elementary fundaments of mechanics and mechanical science."

It is not necessary to dwell at great length on the merits of the "Hornby System." The greatest criticism and the most severe that Hornby could have received came from the boys of England. They wouldn't play with his toy. It wasn't a toy. He so completely bound up their inner urgings with his rigid procedure, he left so little for them to do, he took away from them so completely the possibility to experiment, that Meccano lost its appeal. It took Hornby about five years to realize that in his anxiety to prove that his device was "educational," he had robbed it of the spirit which had given him the original inspiration. In the parlance of our men of business, the Hornby System did not "panout." It didn't attract. It was too "educational" to educate.

Hornby, however, persisted. Some of our modern educational theorists might have told him that teaching through play was an abuse of play, or that he was using play as a means to an end, when play should be an end in itself, or that his procedure was from general principle to application, where it should be the reverse. His own analysis of the difficulty was put in this form: "The boy must have fun; if he learns anything in the process, so much the better." Since 1907, the Hornby System has been virtually extinct. In its place has come the toy that millions of boys all over the world play with.

The aim of the other sets have been conceived in just as an educational manner as was Meccano. To quote from the introduction to one of the Chemistry outfits: "To satisfy in part this thirst for chemical knowledge and to afford the extreme pleasure derived from the performance of the experiments is the purpose of this chemical outfit. We have aimed to make the subject alive, real and amusing by taking for chemical explanation the things one sees and uses every day of his life." As a statement of aim the above compares favorably with recent thought among leaders in science teaching.

In addition to the materials and manuals, the boy is flooded with all sorts of propaganda designed to hold his interest and increase the number of sales.

There the magazines, such as Toy Tips, The Meccano Magazine, and the Chemicraft Chemist, to which he is urged to subscribe. These magazines print his name and address, his correspondence, his picture, and they describe new experiments and answer his questions. Then there are the competitions. As one of the Meccano officials puts it:

"There are four stages in the boy's reaction to Meccano. In the early days of his play, he is bent on getting the mere *experiences* of manipulating real and workable things. In the second stage he is essentially imitative, duplicating what he sees in the manual. In the third stage, he tends to be original, to invent and originate. And in the fourth stage he emulates the accomplishments of others. Furthermore, there is no fourth stage unless there is something he can compare himself with, something he can strive for."

And so thousands of dollars are offered each year for the best constructions and the best experiments; and tens of thousands of boy competitors flood the mails with their descriptions and photographs.

One of the most effective ways employed by the companies to maintain their hold on the boys is to offer degrees of merit. It is hard for adults to appreciate what the International Society of Meccano Engineers can mean to a boy, or to regard with a boy's mind the Gilbert Institute of Engineering or the Chemcraft Chemist Club of America. To receive the degree of "Erector Master Engineer" means quite as much to a boy as the L.L.D. or Ph.D. will mean later on,—perhaps more.

Now, let us see what the manufacturers feel to be the value of their toys,—not the value of their product over that of someone else, but the intrinsic value of this material. Two types of statements are usually forthcoming; one emblazoned in their advertising circulars to parents and adults, and one to teachers, educators, and the sharply-inquiring individual. "Meccano," says Hornby, in one of his magazines, "is valuable because a knowledge of mechanical principles gained early in life is an asset that will count strongly in favor of the boy when he rubs against the real problems of later life." And again, "No boy can play with Meccano without being trained in the principles of mechanics and engineering." But talk to Hornby or his representative and ask him what he feels to be the value of his toy, and he will tell you that he does not

know whether all boys can learn the principles of mechanics, or whether all the principles of mechanics are involved, or how many boys actually learn some of these principles, or even whether they learn any at all. He will talk very assuredly about some things, and will preface most of his statements with "It is my profound belief," or, "It is my positive conviction," etc. From the concrete evidence and personal experience which he does possess, he has ventured one positive statement: "The boy is interested, he is enthusiastic, and he is getting real experience with things."

Gilbert is even more non-committal on the value of this type of toy. To a convention of toy buyers and manufacturers he will point, among other things, to the following basic ideals of his product:

(a) To instill into boys the spirit of leadership.

(b) To bring science down to a boy's understanding.

But Gilbert, in a private conference, will hasten to confess that he does not know what the real value of his toys are. He "feels" that they are worth while. He enjoys helping his boy correspondents. It keeps them out of mischief. They and also he are having lots of fun. And he proposes to go right on perfecting his toys, making them still more popular and in still greater demand.

Without going into further details, it is clear that parents are being flooded with vague, exaggerated, and baseless claims for values that may or may not exist, or values that may or may not be values. It must be very emphatically pointed out that we have not yet been educated to the point where we will look upon the activities of the child when he is out of school with as critical a mind as we regard what he does while within school walls. Furthermore, it is not quite clear how the various studies and researches which have developed our conception of curricular values can be applied to extra-curricular activities. So that even the parent who is keenly awake to the need of marshalling proper influences around the child at all times, has no criteria by which to judge or control the type of materials which are here considered. It is not uncommon to find the chief value of a toy to be the fact that it "helps keep my boy out of mischief," or that it is "the safest and sanest thing I have yet bought," or "It is very inexpensive and absolutely

noiseless." These expressions do not always bespeak unintelligence or lack of parental interest in the welfare of the child. It is a far greater indication of the failure to utilize for the development of the child certain forces that are as important as its "schooling."

Play, as a factor in education, is of course not new. Some of our leading educators throughout the ages have given it special thought. Plato was the first to give it prominence. And since Froebel wrote his "Occupations" we have had a long list of experimenters and writers on the subject. Spencer found as the chief function of play the fact that it furnished an outlet for the "surplus energy" of the human organism. Groos and Fiske looked upon play as "nature's method of education," as activity peculiar to "infancy" and of value in preparing for adult life. Later the above theories gave way to G. Stanley Hall's "race recapitulation" theory, and even this theory has been successfully attacked by writings of men like Dewey, who look upon play as being just one phase of the normal life of the child—important in its own right and worthy of being an end in itself. As Merriam puts it, in his book on Child Life and Curriculum, "Education through play is a misconception and an abuse of play. Play through education is a more valuable concept."

The tendency then among educational thinkers is to establish values for play activities that are in a different sphere or on a distinctly separate plane from curricular values. This may ultimately be developed in as detailed and thoroughly applicable a set of criteria as we have for curricular studies, but in the absence of these newer standards there can be no more valuable evaluation of the materials and activities we are here discussing than to compare and contrast them with activities of the classroom. Whatever the standards are that we apply to school work, how will the Meccano boy and the Gilbert boy measure when the same standards are applied to them? Obviously an answer to this question will orientate our problem, and is the very first question to settle, because it will determine to a large extent whatever else may follow.

The science activity that most nearly parallels play with science toys, especially for the boy of the age that we are considering, is the course in elementary or general science. A

close study of the recent trend toward a first course in science brings to light one large aim from which the values of the study are to be derived. There has been considerable discussion, and in many cases even bitter disagreement, as to choice of content, its organization and method of instruction, but there has now evolved almost unanimous agreement that General Science or Elementary Science or the First Course in Science should aim to acquaint pupils with their environment. Other aims, and especially their relative importance and desirable emphasis, are still very much mooted questions, but that environmental science is the starting point for all writers of texts and framers of courses of study, there is now general agreement. The chief worth of classroom science activity is the increased knowledge, appreciation and control of the environment; the street environment, the newspapers, the theater, etc., are all analyzed for the elements of science that they contain, and materials and activities of the classroom take their origin in them.

Next to environmental knowledge and environmental control, there is greatest agreement on the proposition that we should teach science so as to enable our pupils to appreciate the method of science and to use this method and the thinking procedure of science in their everyday lives. Obviously there are several aims involved in this proposition. Some of our leading educators in science teaching, who realize the limitation of a beginner's course in science, are content if this course but serves to inspire boys and girls to further study of science. Eventually the value or values sought are the habituation of the individual to the greater use of scientific thinking and experimenting, and possibly the development of those individuals who can contribute to the advancement of science in the way of discovery and invention.

To these two groups of major aims from which evaluation proceeds, there are usually put forward other aims which, though very important, have not received the same degree of general approval. General or Elementary Science is taught for its civic value, for its vocational value, for its avocational or cultural value, and for the enthusiasm and interest which it arouses in a large proportion of any class: civic value because of the large number of commercial, city, state and national

functions that are intimately tied up with the practical applications of scientific laws and principles; vocational value because of the inspiration that frequently comes to a boy or girl to choose some field of science as a life work due to the discovery of an "original" talent. This discovery usually comes through contact with the materials and activities of the science course. Avocational value is claimed because of the larger applications which are made possible by a study of science. The universe, the heavenly bodies, the forces of nature, all offer real aesthetic experiences that are heightened by a keener understanding of them. And, of course, science has been the source of the greatest proportion of life hobbies of the more genuine kind. Finally, the mere enthusiasm evoked by a well conducted course in science is always a desirable characterictic about a pupil, because it furnishes a hold on him which can be utilized in many ways to further the general efficiency of instruction.

Accepting the above analysis of aims and their corresponding values for curricular science—especially that science which is commonly given to a boy during his "toy age"—it is proposed to also adopt the analysis for extra-curricular science. To recapitulate, and in terms of our after-school materials, the criteria which give a science activity value are these:

(a) Does it make for an effective increase in the knowledge of the science of our environment and of its control? That is, does playing with toys help a boy to know better—
  What things are?
  Why things happen?
  How things work?
  How things are made, and
  How things are used?
  Does it also give one greater skill in—
  Using things and
  Making things?
(b) Does it increase his ability to construct? That is, does it make him more adept at manipulating things and does it increase his ability to fashion raw materials into usable things?
(c) Does it make for experimentation and inventiveness? That is, does it inspire the boy to experiment, to try out new things, new ideas, new combinations, and to test these ideas in experience?
(d) Does it have vocational value? First, will it inspire one to further study of science? And, second, will it inspire one to take up a certain vocation?
(e) Does it have civic value?
(f) Does it have avocational value?

(g) Does it involve an attitude or spirit of work that is in accord with—
  I. Dewey's "Interest and Effort."
  II. Thorndike's "Law of Set or Attitude."
  III. Kilpatrick's "Purposeful Activity."

Having thus set up criteria for measuring the educational value of play with scientific toys, the first essential was to bring this play under as close observation as was the classwork in science, and yet not deaden its spontaneity in any way. This was accomplished by means of a Science Club, with a program of activities that brought the boys into the school for some of their "play."

A second essential was a common ground; that is, a common body of content, so that the comparison would be a fair one. This raised a serious problem. To teach the things that boys will play with is to introduce a control on teaching that may work to its disadvantage. To make boys play with the things they are taught (if that were possible) would be to destroy completely the "play." To solve the problem two procedures were adopted. During the year 1919-1920 the play was permitted to go on uncontrolled, as was the teaching. At the end of the year a good deal of overlapping was found to exist. Tests based on this overlapping material were used as a means of measurement. During 1920-1921 a series of play units were chosen on the basis of the most popular toy, and the entire course of study for the year's teaching was developed from these play units. Thus the teaching was "controlled," as was also the play to a lesser extent, and the tests given were entirely on an identical body of content.

During the two years the comparisons drawn were among four groups of almost equal mental age and I. Q.[2] Group A in both cases had not only the teaching but also the play. Group B had only the teaching. Group C had only the play, and Group D had neither. The last group was introduced as a control group?

During 1920-1921 the total amount of time spent on teaching was twenty periods of 30 minutes each and twenty periods of

2 Groups C and D were drawn from the Fifth Grade, whereas Groups A and B were drawn from the Sixth Grade; thus the former were on the average one year mental age younger than the latter.

15 minutes each, allowing 45 minutes during each week up till the end of March. The time allotted to play was a 35 to 45 minute period a week for 20 weeks.

At the end of each year, four types of tests were given to all groups. There was first the traditional type of test that teachers usually employ to find out what knowledge their pupils have carried away. (The Written Test.) Second, a test was arranged in which a series of phenomena were enacted before the class, the latter being given two minutes for each phenomenon in which to write their explanation and understanding of what they had seen. (The Visual Test.) A third test was one in which each pupil was asked to do certain tasks with actual materials. (The Practical Test.) And finally, as a measure of constructive ability, the Stenquist Box Test was used, both at the beginning of each year and at the end.

Here are a few of the significant results (averages) of these tests:

Group	*Average I. Q.*	*Stenquist No. 1 (before)*	*Stenquist No. 2 (after)*	*Visual*	*Practical*	*Written*
A.	110.5	55	64.4	73.5	73.6	65.3
B.	113.0	52	50.5	57.2	40.2	50.7
C.	107.6	36.4	47	42	53.6	37.1
D.	110.8	37.6	36.8	27.4	19.8	8.2

Though Group A shows superiority throughout, and Group C (after a year's mental age difference is allowed for) shows superiority over Group B, even in the Written Test, it is in our second general aim, environmental control, that the value of our play materials becomes marked.

In the type of ability represented by the "practical" tests, Groups A and C are far superior to the rest. In a sense, environmental control is more important than mere knowledge or information, for it involves the functioning of this knowledge in life situations. How often do we remark upon the vast chasm that exists between being able to explain to the physics teacher how an electrical bell works and the ability to repair the house door-bell. The utter helplessness of the average individual who is confronted with a balky vacuum-cleaner or an electric socket that won't work, or a blown fuse, or a leaky water faucet, is regarded by many as a sad phase of modern city life. We rely too much upon the mechanical expert who weaves around himself the autocratic halo of the physician,

and who regards poor ordinary mortals as incapable of understanding what ails them, or rather their house appliances. Just as in medicine, so in things mechanical and electrical, we ought to encourage and train individuals to care for their physical belongings intelligently. The ounce of prevention maxim holds just as truly in this field as in medicine. If the course in hygiene aims to make the doctor a less necessary commodity, so after-school activities in science can serve to make less necessary the plumber and the electrician. The most interesting result of the practical test is the small amount of carry-over or transfer which there was between the class-work and the ability to do the actual tasks with materials. It is clear from the table that the curricular work did not help Group A in getting their high score in this test, for Group C, without the curricular work, did better than the much older boys of Group B. In this connection, we might mention again the common criticism of modern society, as expressed in the writings of Dr. Eliot and others, in which the loss from the home of opportunity for sense-experiences is very much regretted. The writer wishes to point out that this opportunity still exists, but in a different form. In a sense, there are more of these experiences possible; they are more interesting and involve a greater amount of intelligence and knowledge. The stimulation to such experiences is furnished to a great extent by these after-school activities in Science.

To summarize briefly the conclusions and items of interest uncovered by this study, we may list the following:

1. In general the very expensive toys are not more educational or more fun-producing than are the less expensive ones.
2. The number of toys a boy possesses increases until he is eleven or twelve years of age. The number stays constant until he is fourteen; when it begins rapidly to decrease.
3. At fourteen years of age there is a marked change in the type of interest that a boy has in toys. Though after-school science activities do not diminish appreciably, there are no toys sold which meet his needs completely.
4. The toy outfit is far more popular than the specific toy. (An outfit is distinguished from a specific toy chiefly by a greater wealth of experimental possibilities and original adaptations.)

5. Of the five hours of each day that the average Horace Mann boy has free to do with as he chooses, roughly three hours are devoted to science toy activities of various kinds; the other two to athletic games.
6. Activities with science toys come at irregular intervals and for long and protracted periods. They are usually accompanied by great enthusiasm and often by dreams at night and by day.
7. A large proportion of boys who own science outfits carry on correspondence with the manufacturers of their toys. As many as 2,500 letters a day have been received by one firm during the months of November, December and January.
8. An analysis of several hundred letters shows the chief interest (37% of the boys) in these toys to be a desire to "do things, make things work, make experiments, and invent." The interest that ranks next (23%) is in the winning of a prize or diploma. The interest that ranks third (20%) is in being a great engineer or inventor.
9. Most of the letters are written because the boys wish help. The chief source of difficulty (54%) of the letters is due to lack of knowledge. The difficulty next in importance (25%) is due to highly impractical schemes. Lack of ability or technique accounts for 18% of the difficulties.
10. As shown by the letters, two-thirds of the boys succeed in overcoming their difficulties. One-third fail. Half of those that succeed do so because of continual experimenting,—trial and error. The other half succeeds through help or hint from parent, teacher or friend.
11. The companies do practically nothing for the one-third that fail.
12. The chief characteristic about a boy who succeeds in overcoming a difficulty is that he almost always finds a new problem arising out of the old one.
13. For every boy who follows the order of the experiments as found in the manual, there are seven who skip around throughout the manual, performing experiments at random. The manuals do not function as they are intended to by the companies.
14. The "random" boys are superior to the others in inventiveness and originality (as measured by their standing in the Science Club).
15. Many of these "random" boys develop a steadier interest in the manuals later on; that is, they pay more and more attention to larger ideas and concepts as developed by the manual. Guidance and control at these critical stages is, of course, important and is furnished to some extent by the club.

16. The mechanical toy of greatest appeal is the electrically-operated derrick that moves and lifts.
17. There is a growing tendency among manufacturers to abandon the type of toy that appeals merely to the two elementary sensations of motion and color, and to produce a toy that is "meaningful." This tendency is the correlate of a great demand for this sort of toy that is world-wide.

Applying curricular standards to this activity we find, that—

18. Extra-curricular activities in science make for better control of the physical and chemical elements in our environment.
19. Extra-curricular activities in science make for almost as good a knowledge and appreciation of environmental phenomena as do curricular activities.
20. Extra-curricular activities in science make for better constructive ability; that is, ability to fashion raw material into usable things.
21. Extra-curricular activities in science encourage and stimulate activities that give the boy first-hand experiences with natural phenomena. Their activities agree closely with the useful activities of great scientists and they contain elements in common with the laboratory procedure of great scientists.
22. Extra-curricular activities in science represent a type of purposeful activity which encourages originality and inventiveness and habituates boys to the experimental procedure.
23. Boys who participate in both curricular and extra-curricular activities excell all others in the abilities mentioned above.
24. Clubs and societies for boys of the ages 11, 12, 13 and 14, take advantage of an instinct that is very dominant during those ages. The propaganda of the manufacturers, the different toy institutes, etc., utilize this instinct essentially for their own purposes.
25. Experiences of large organizations of this type in the past show the need of three things: workable materials, a definite program, and intelligent leadership.
26. The Science Club is an organization which may serve as a medium through which the after-school activities in science may be stimulated, guided, controlled and developed.
27. The Science Club should have a science play-shop, where are offered the proper physical facilities for the efficient carrying on of after-school activities *in school.*

What the Pupils Want in the First Year Science Class[1]

E. B. Collette, Lake View High School, Chicago, Ill.

There are a few comments relating to the teacher, the pupils would like to make about things that go on in the classroom.

Pupils want the teacher to be and act like common human folks and not use so many big words.

They don't want the teacher to practice on them with a lot of technical college ideas that they can neither grasp nor get interested in.

They want to remind the teacher that it is pupils he is teaching, and not subjects.

They wish the teacher could appreciate how they think, and what things they understand. Too many of the things taught are of interest only to a mature mind.

They wish the teacher could understand that if they are not interested in the work, usually it is the teacher's fault; another teacher might take the same topic and have them happy, interested and eager to take part.

They want the teacher to take a little more time and not go over things so fast, if they are worth while, and give them a chance to think, Most of the questions a teacher asks are put in a way that is new to them, and they don't have answers already formulated in their minds, even if they do understand what it is all about.

They think it would be great sport to answer questions the teacher asked when he honestly wanted to find out something. For example, a teacher once asked the pupils how to cook mushrooms, and admitted he didn't know how; and what a storm of answers the question brought forth. He almost needed a rope to keep the pupils from crowding around his desk to tell him all about it.

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1 Paper given at the Central Association of Science and Mathematics Teachers.

They think it takes all the pleasure out of recitations to be asked questions, when they know the teacher knows the answers and is only waiting to criticize the words they use and the ideas they have. You remember one day Min was scolding Chester when he came home with face and hands all covered with dirt. She said, "What would you say if I came home with hands like those and you saw me?" Chester frankly replied, "I wouldn't say anything; I'd be too polite."

They think the average teacher is still barbaric in his attitude towards pupils—possesses immeasurable vanity, and frequently ignores and frowns down upon the pupils' complaints and ideas.

The teacher is supposed to be interested in developing personality. Personality is developed from within. He wants these pupils to react on their environment. He wants them to become first-rate masterpieces. But if the teacher seeks a subservient attitude, if he seeks to have the "obedient" or "anxious to please" pupils, the weaker-willed ones will adapt themselves comfortably to his dictates,—those of stronger wills will rebel,—but in so far as such teaching is successful and the subservient attitude does predominate, he has in result only second-rate copies, when he might have had first-rate masterpieces.

Yes, pupils think the teacher fears the footfall of the younger generation, and instinctively desires to retain power by holding them in check.

* * * *

The pupils want a chance to understand the Scientific Method. They want a chance to understand how it is different from other methods with which they have had experience. It could be explained clearly in the class-room and compared with other methods of getting knowledge. All through their lives they have been handed ideas, and in a good many cases, have never dared to draw, or even thought of drawing, their own conclusions from facts presented. If there is a correct way to reach conclusions they want to have experience to try it out, see that it works, and learn to believe in it. And you may be sure they are going to watch the teacher to see if he believes in the Scientific Method and practices it in his thinking. Take a homely example for illustration. They have been taught

ever since they can remember, to "swat the fly." In the science class they get the idea of the fly's life history, and with a little guidance from the scientific teacher, they may quickly grasp the idea of how screens on our houses, fly-swatting campaigns, and even interest in the great varities of fly-traps and fly-papers, are so ridiculous as compared with the careful control of breeding places in the community.

Pupils sometimes wonder about things a great deal more than we teachers realize. They have wondered, lots of times, about what education really is, and what it is for. Usually we have not made it very clear to them.

Under the name of education they have been disciplined, which is not education at all, but simply a form of guardianship. They have been told to do this and not to do that. Sometimes they have been told why certain things are good for them, and why certain things are injurious. But usually this guardianship has had but little to do with their welfare or rights. They have been guarded, too frequently, with standards of old worn-out customs which result in less irritation and inconvenience to adults rather than the best interests of growing boys and girls. If they respond meekly, have pleasing dispositions and manners, they are likely to be petted and spoiled, become followers and learn to practice dishonorable submission to the authority of another instead of self-reliance. When some are more independent and less tactful, they are more likely to be tormented, given less consideration and lower marks, and because they seek the right to decide things for themselves they frequently become evasive, cowardly and deceitful.

Under the name of education they have been trained, which again contains very little education; trained to travel beaten paths because others have traveled them. A teacher has called one training good and another bad, very frequently with no consideration at all as to the real welfare of the children. The teacher has handled them in "job lots," imagining that a well trained class shows signs of education, when, in reality, it frequently shows education is becoming more and more impossible. How true the statement: "We are a mass of people living in a submissive routine to which we have been drilled from our childhood."

And it is no wonder pupils want to know what education is, and what it is for. They don't get it in guardianship, good or bad though that may be. They don't get it in correct or incorrect training. If they ever deserve to get it, and if there is the slightest chance of their ever getting it, it is in the Science class. They really want, and they deserve to get, a chance to think.

These pupils want to be freed from the insidious ghost fear. Even in our "enlightened" age, a teacher frequently trains pupils to be afraid. He who instills into the heart of a pupil the fear of being scolded, fear of ridicule, fear of shaming before a class, fear of low marks, fear of failure to pass, fear of making mistakes, is inevitably blocking the possibility of real education.

There is no education without freedom from haunting fear. As soon as we draw the line as to what pupils should think we make it impossible for them to think at all. The teacher who educates is never anxious about what pupils think. To be uneasy is the sign of a teacher's aim at training. It is the science teacher's privilege to see that pupils get hold, and learn how to get hold, of scientific facts. What the pupils do with these facts is the process of education; and at such a time these growing minds must be free from fear, for the human mind is so constructed that fear is the greatest enemy of thought.

Why should we be uneasy, or even particular, about what conclusions pupils draw from well-organized scientific facts presented? Are we afraid of the unbeaten paths? Does the spirit of science tell us that pupils are not to explore or investigate the new roads ahead? It does not. Does it say the conclusions of the youth must be the same as ours have been? It does not. Are we teachers really scientific in our thought when we fear or hesitate to draw scientific conclusions different from old customs, habits and creeds of days gone by and of an age that is dead? Are we young enough in our thought to be leaders of the youth who are to live in the coming days of change and progress? Are we really seeking to educate pupils in our science classes, or do we want to produce a certain type of character to serve subsequent ends? A real science teacher is not afraid of, but is happy over, the newness of thought of the growing generation.

The pupils want to be freed from superstition. They are living in a day when science is coming into possession of its own. Many old superstitions, customs and beliefs are being cast into the discard of forgotten things. These pupils realize that many things are out of date, but quite generally they lack the scientific background of why newer customs and ideas are more accurate and true. It may be a science teacher is more superstitious than the pupils. He may have the superstitious idea that we are to follow leaders; be dictated to by others, rather than to be thinkers and builders for ourselves; that ideas handed down from generation to generation—unscientific as they may be—are to be believed; that statements in print must be true, even if coming from most widely circulated newspapers; that social and political standards are correct simply because they have been in practice; that men of leisure and culture are to be respected and looked up to, rather than those of the labor world who bear the burdens and run the risks of life. The teacher may lift a heavy burden from the shoulders of our youth by knowing scientific facts that relate to life, helping pupils to get a foundation, during these changing days, that will permit them to understand the kind of a civilization that man has built, and how, most effectively, our younger folks may stand constructively for truth and justice in a more scientific civilization than the past has been. They need our help in hammering down the walls of superstition and ignorance. It is the old struggle of light against darkness; knowledge against ignorance; truth against superstition; freedom against fear.

The pupils want a chance to understand the perplexities of life. The day has come when further suppression of economic knowledge is most disastrous to human welfare. The pupils of our schools are quite commonly taught errors and kept in ignorance about the simplest economic facts. Yet that nation is most fortunate whose youth is taught truth—vital truth—applying to life and the happiness of mankind.

For example,—Pupils very easily grasp the scientific laws about tuberculosis. They can readily understand this disease alone costs the people of our nation about one billion dollars a year, and that by following a scientific program it can be eradicated, instead of having most of our attention given to

curing cases, when the cause of the disease is so largely neglected as unimportant.

Another example,—They learn about the wonderful scientific development of the dairy breeds of cattle, the egg-producing wonders among chickens, the endless varieties of marvelous fruits and flowers, and these pupils in the public schools also know something about the thousands of babies and school children who sicken and die from insufficient nourishment, having had but little opportunity to ever appreciate the beauties of the flowers. These pupils wonder why, in a nation of plenty and scientific progress, we must have these unnecessary deaths and the flowers kept from those who would appreciate them the most.

Again,—They study about the power of nature man has scientifically harnessed, the machines and inventions developed by which the work of the world is being done, intended to relieve mankind from monotonous drudgery and slavery; but in every industrial center they know something of the bitter struggle betwen the masters of industry and the wage-workers over the length of the working day and rights of individuals. These pupils know something is wrong when a new machine is put into use, and instead of lightening men's burdens, has the effect of throwing more men into the unemployed group, which already numbers millions in the United States alone, a disastrous situation which is receiving but little serious consideration.

Pupils should have opportunity to appreciate the dignity of work,—work that is valuable to themselves and the community. They see life with unemployment, starvation and monotonous drudgery, and mangled with scientific warfare, instead of its becoming more happy and free and filled with opportunity for creative work. They wonder why these marvels of science do not apply much more to life. The teacher must understand the scientific facts—not become a peddler of cheap propaganda—but help pupils to see how science may and must relate to the solution of our civilization's most serious problems.

The pupils of our cities want lots of things that they know not even of. Luther Burbank puts it nicely, when he says: "Every child should have mud-pies, grasshoppers, water-bugs,

tadpoles, frogs, mud-turtles, elderberries, wild strawberries, acorns, chestnuts, trees to climb, brooks to wade in, water-lilies, woodchucks, bats, bees, butterflies, various animals to pet, hay-fields, pine-cones, rocks to roll, sand, snakes, huckleberries and hornets; and any child who has been deprived of these has been deprived of the best part of his education." But our machine-made civilization, with its tangle of tenement-flats, stale air, nerve-wracking jobs and noises, cement and cinders for playgrounds, so-called living-wage schedules, cheap stale foods, the haunting fear that ever dogs the steps of adults and youth alike,—this is the scientific problem of our day. And he, who in a science class dares to teach less than scientific truth, leaves a heavy load for the children to carry; and if there is any law of right written in the book of life, it has been broken.

George Bernard Shaw has said: "Liberty is the breath of life to nations; and liberty is the one great thing that parents, schoolmasters and rulers spend their life in extirpating for the sake of an immediately quiet and finally disastrous life."

Fear and slavery are enemies of life, stumbling-blocks in the road to scientific liberty. They haunt the children in the classroom. They say don't dare, don't seek to know, don't wonder why. The science teacher holds a key to the door of liberty and knowledge and light. Let him have wisdom and vision and love of truth, that pupils may enter into the joys of life, of work, and of service for the coming day.

A New Test in General Science

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In the *General Science Quarterly* for November, 1919,[1] the writer described the construction of a preliminary test in general science which he termed a "Range of Information Test." The term *test* does not fairly describe the nature of these materials, which were in reality merely lists of common terms, concepts, structures, etc., which had been assembled by careful analysis and classification of the subject matter of twenty-two text books and manuals in general science. It is unnecessary to enter into the details of the derivation of these lists of terms in any very great detail, except as they throw light on the construction and standardization of the newer test which is to be described. The reader is referred in this connection to the paper cited above, as well as to a second article in this journal under the date of November, 1920.[2] The second paper gives certain data on norms and correlations of the Range of Information Tests with school marks and intelligence, etc.

The demand for these preliminary tests proved so great that it was evident that teachers throughout the country were agreed that reliable measures of general science abilities were very much needed. In order to encourage the use and construction of objective measuring instruments, the writer, with the assistance of Mr. Herbert F. Popenoe of Stanford University, undertook the task of revising and extending the *Range of Information Test* into a scientifically constructed educational test. The revised form of this test is published by the World Book Company, Yonkers, New York, under the title of the *Ruch-Popenoe General Science Test.* The new tests are published in two approximately equivalent forms designated as Forms A and B. The details of the construction of the *Ruch-Popenoe General Science Test* will be presented under the several headings which follow.

1 Ruch, G. M.: A Range of Information Test in General Science, General Science Quarterly, 4, 1919, 257-262.

2 Ruch, G. M.: Range of Information Test in General Science: Preliminary Data on Standards, General Science Quarterly, 5, 1920, 15-19.

Validation and Description of the Tests.

It has been stated that the materials for the original *Range of Information Test* were obtained by the analysis of the contents of twenty-two textbooks and manuals in general science. This list of books included all of the texts published up to 1919, with the exception of one text which had been withdrawn from the market. All of the terms used in any of these texts were listed, and the number of texts incorporating each term was determined. The number of texts presenting discussions about any given term or concept was taken as a rough measure of the general validity of that item of subject matter for use in courses in general science, and, as a consequence, of its validity for purposes of measurement. The argument for the soundness of this method of selection of test materials might be stated by saying that, by and large, what the majority of textbooks present is likely to be fairly representative of what the majority of teachers teach in their general science courses. It is quite obvious that this is far from a perfect criterion of what should enter into a test of general science, yet, it is true that, during the formative period of any new subject, the textbooks do determine to a very marked extent the content of general science courses in the great majority of schools. Our analysis of 1919 showed that there were about one hundred and fifty items which were common to at least half of all of the existing textbooks, and this degree of agreement among the twenty-two texts was taken as a satisfactory working basis for the selection of test items. All other items were rejected, even if they seemed to be perfectly valid and useful concepts. In this way it has been assured that the test elements are those most likely to be given considerable prominence in general science teaching. In producing the present tests, several additional texts, published since 1919, have been added to the original list.

It is desirable to digress at this point to the extent of inserting a brief description of the *Ruch-Popenoe General Science Test,* in order that the explanation of the validation of the tests can be made clear. The new test consists of two parts. Part I include 50 items of the information type, designed to sample as widely as possible in a limited amount of time a fairly wide range of simple facts, drawn from the fields of botany, chem-

istry, physics, zoology, astronomy, physiography, geology and physiology. The facts involved call for knowledge of elementary scientific principles, terms, definitions, concepts and applications. Seven possible responses are given to each question asked, and the pupil is asked to underline the correct answer. (See the sample items on a later page.) Part II of the test consists of twenty diagrams and drawings, together with completion exercises based upon each of the illustrations. These drawings and exercises were designed to measure the ability of the pupil to identify apparatus, structures, organisms, principles, etc., and to apply such principles to the solution of simple problems. The pupils need only write the correct word on each blank line, and in most cases only one response is acceptable for credit. There are several acceptable responses in certain cases, but these are definitely specified in the manual of directions published for use with the tests. It will be noted that the scoring of Part I is entirely objective and that of Part II is practically entirely objective. The diagrams for Part II of the test were validated by the same method of analysis of textbooks, except that the items were also submitted to a group of competent teachers for additional ratings for desirability. The chief argument for the use of drawings rests on the fact that this type of test material resembles much more closely the laboratory aspects of teaching than does the purely verbal information test. Moreover, pupils respond with greater interest and effort to the illustrative test materials. The drawings have purposely been very much simplified to the exclusion of many of the not strictly relevant details. (See samples on a later page.) The use of drawings enables the teacher to measure a number of types of knowledge which do not lend themselves to the purely linguistic procedure of most educational tests, an advantage which is particularly significant in the case of the natural sciences.

In order to illustrate the nature of the tests as concretely as possible, a considerable number of the test elements are reproduced here.

EXTRACTS FROM PART I.

DIRECTIONS:

Draw a line under the one word that makes the truest answer to the question as shown in the sample.

Sample:

An example of a liquid is iron glass air water lead zinc oxygen

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Begin Here:

1 Pneumonia is a disease of the heart liver lungs brain stomach muscles kidneys 1

2 Volcanoes are most likely to be found in deserts valleys coastal-plains mountains deltas interiors islands 2

3 Distance above sea-level is called longitude rotation altitude latitude declination revolution inclination 3

4 The earth rotates on its axis once in 12 hours 24 hours 7 days 31 days 3 months 365¼ days 4 years 4

5 An example of a rock which weathers rapidly is granite marble slate schist augite obsidian limestone 5

.....

21 A mirage is a kind of swamp rainbow body of water optical-illusion vision desert warfare 21

22 Decaying vegetable matter in the soil is termed fungus nitrates mineral phosphates lichens potash humus 22

23 The smallest of the planets is Mercury Venus Mars Jupiter Saturn Uranus Neptune 23

24 The length of a meter in inches is about 12 19 27 39 47 72 144 24

25 A general term for any living thing is a plant cell larva animal organism mammal nucleus 25

.....

41 An example of a leguminous plant is the willow clover toadstool pansy lilac moss maple 41

42 An example of an alkali is aluminum lead-oxide sodium-hydroxide table-salt mercury potassium-chlorate glucose 42

43 The distinguishing feature of the mammals is the possession of backbones hair two pairs of legs warm blood teeth milk glands nervous systems 43

44 The one of these substances having the highest specific 44

heat is water iron glass lead copper soil rubber

45 "Hypo" is used in photography as a developer fixing-bath intensifier reducing-agent bleaching-agent sepia-toner hardening-bath 45

The 50 items similar to those given above are arranged in the approximate order of difficulty as determined by giving the tests to several hundred pupils in general science classes and computing the percent passing and failing each separate item. The use of seven response words has been adopted in order to reduce the chance element. With seven responses stated, the pupil who is merely guessing cannot earn any considerable score. The effect of this reduction of the chance element is very evident in the figures given later for the reliability of the tests. Fifteen minutes is allowed for completing Part I. This amount of time is generally much more than is actually needed by the average pupil and hence the test is virtually a "power" test more or less completely independent of the "speed factor."

EXTRACTS FROM PART II.

DIRECTIONS:

On the following pages are twenty diagrams. . . . There are a number of questions about each of these diagrams. Begin with the questions on Figure 1, study the questions and the diagrams and then fill in the blanks which have been provided for your answers. In most cases you will need to write but ONE WORD in each blank.

BEGIN HERE.

Figure 3.

In this diagram of a typical flower:

a. The petals (the corolla) are marked by the letter.....
b. The stamens are marked by the letter .....
c. The sepals (the calyx) are marked by the letter.....
d. The pistil is marked by the letter .....

Figure 7.

a. This is a drawing of a ....
b. The piston is lettered ....
c. The valve which opens on the upstroke is lettered .....
d. The greatest distance that valve C can be placed above the level of the water at D, if the instrument is to work successfully, is about ..... feet.

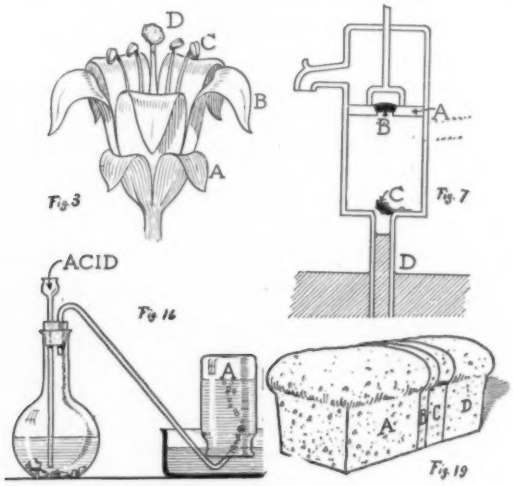
Figure 16.

a. In the apparatus shown, some hydrochloric acid has just been poured into the thistle tube so as to act on the bits of marble (limestone) in the flask. The gas which is being collected at A is .....

b. If this gas is passed into ..... a ..... will be formed.

Figure 19.

In this loaf of bread, the food materials which are contained in bread are shown in rough proportions by the parts A, B, C, and D.



a. The fat content is the section marked by the letter .....

b. The carbohydrate content is the section marked .....

c. The water content is the section marked .....

d. The protein content is the section marked .....

Part II consists of twenty such drawings with a total of 80 blanks to be filled in. The score on this part of the test is the number of blanks correctly filled in divided by two. The quotient is then added to the score on Part I which is obtained by simply counting the number of correct underlinings. Twenty-five minutes is allowed for Part II, a total of 40 minutes of working time for the entire test. About 90% of ninth grade

pupils find time to attempt every item in the test within the time limits allowed.

In addition to the validation of the older *Range of Information Test,* the *Ruch-Popenoe General Science Tests* have been carried through two further try-outs. The preliminary one involved about 250 pupils representing a sampling of 10 schools in 5 different states widely separated geographically. These results were used to obtain the per cents passing each individual item and for equating forms. The second try-out was held for the purpose of determining reliability co-efficients and obtaining further data on norms. Tentative norms based upon 363 pupils drawn from 12 different schools and 6 states are now available. More reliable norms will soon be available.

THE RELIABILITY OF THE TESTS.

The following reliability co-efficients have been computed by correlating the results from Form A with those from Form B. All of the reliability co-efficients are based upon the Pearson product-moment formula,

$$r = \frac{\Sigma x y}{N \sigma 1 \sigma 2}$$

TABLE I.

RELIABILITY COEFFICIENTS FOR THE RUCH-POPENOE GENERAL SCIENCE TEST.

School—State	*N*	*Part I only*	*Part II only*	*Entire Test*
1. Westinghouse, Penn.	48	.69	..	.81
2. University High, Oreg.	23	.76	.74	.87
3. Grand Rapids, Mich.	42	.64	..	.80
4. Palo Alto, Calif.	22	.78	.69	.85

If these separate reliability coefficients are combined into a weighted average, the reliability of a single form appears to be about 0.82. By the use of Brown's formula, $r = \frac{n\,r}{1 + (n\text{-}1)\,r}$, the reliability of the sum or average of both forms is estimated as about 0.90. If the reliability of a single form be conservatively taken as 0.75, the reliability of the sum or average of both forms is about 0.86.

The probable errors of a single score (the probable error of a score being taken as the average divergence of the obtained scores from the "true scores," i. e., the average of an infinite number of similar forms of the test) can be computed by the formula, $P.E._{score} = 0.6745\sigma_1 \sqrt{1 - r_{12}}$ as being equal to about 4.2 points in terms of the test units. It should be noted that the value $0.6745\sigma_1$ is taken as $\frac{Q_3 - Q_1}{2}$, or, $\frac{44.6 - 24.9}{2}$ (these numerical values being taken from Table 2). By similar methods the probable error of the average score from both forms of the tests would be about 3.0 test units.

Table 2 gives tentative percentile norms.

Table 2.

Tentative Percentile Norms Based on 363 Cases.

90% of ninth grade pupils reach or exceed a score of 18.8
75% of ninth grade pupils reach or exceed a score of 24.9
50% of ninth grade pupils reach or exceed a score of 34.7 (Median)
25% of ninth grade pupils reach or exceed a score of 44.6
10% of ninth grade pupils reach or exceed a score of 53.4

Analysis of Subject Matter.

Table 3, which follows, gives a rough analysis of the content of the tests as drawn from the various natural groups of the special sciences. It will be noted that this analysis is a fairly close agreement with the published studies on the contents of general science courses which have been published from time to time.

Table 3.

Analysis of Subject Matter.

1.	Biological sciences (botany, physiology, zoology, etc.)	30%
2.	Chemistry	12%
3.	Physics and mechanical applications	38%
4.	Earth science, agriculture, astronomy, physiography, etc.,	20%

Uses of the Ruch-Popenoe General Science Tests.

The tests described will prove of value to teachers of general science in several ways:

(1) By furnishing a more reliable and objective method of assigning school marks than that of the subjective judgment of the teacher alone, or that of the traditional examination methods.
(2) By providing a more secure basis for the determination of promotions and failures.
(3) By permitting comparisons between sections, classes, and even different schools and teachers.
(4) By furnishing a basis for the classification of pupils into fast- and slow-moving sections for purposes of giving special types of instruction or enrichment of the curriculum for the abler pupils.

In connection with uses (3) and (4), it is strongly urged that a good intelligence test be given at the same time that the general science tests are employed. Both educational and mental ability must be utilized in sectioning classes and in making comparisons between groups of pupils, whether sections, classes, or different teachers or schools. It is impossible to interpret the results of educational tests, even where reliable norms are available, without recourse to the results of mental tests as a basis for estimation of the kind of talent involved.

It should further be borne in mind that, in the case of high school tests at least, almost every purpose of educational measurement is served by a valid and reliable test, whether norms are available or not. The main issue is that of distributing pupils of a class or school along a scale of ability in such a way that grades may be assigned and promotion or failure can be fairly determined. After all is said and done, we must of necessity turn the scores in educational tests into some arbitrary and prearranged grading scheme, and for this purpose all that we need is to develop a technique of placing pupils along a scale of ability as has been suggested.

The writer is greatly indebted to a large number of science teachers throughout the country for co-operation in the try-outs of this test. The World Book Company, through the courtesy of Dr. Arthur S. Otis, test editor, kindly gave permission to reproduce parts of the tests and the *Manual of Directions*. Samples of this test can be obtained by writing the World Book Company, Yonkers, New York.

Science and Americanism in Industry[1]

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GENERAL science, biology, physics and chemistry, are all departments of science, and hence are interested in any specific department that is working for the advancement of science. These different branches of science are related, and when we discuss the relation of one to industry, we discuss the case of all. Illustrations of such an inter-relation are numerous. Let us consider the case of chemistry and its relation to industry, or rather, let us consider the chemical industry in the United States.

The point is made here that we need to foster and "boost" such an industry from an American point of view. Why must this be done? In order to maintain our independent national status. This may seem like a strange statement, but it can be easily shown that the chemical industry which furnishes the dyes, pharmaceuticals, heavy chemicals, pigments, peace-time explosives and countless other substances, is the industry that in war time furnishes us with the high explosives, propulsive charges and poison-gas of modern warfare. The plants and the machinery contained therein, the organizations, the trained personnel, chemists, engineers and skilled operators in the plant, the crudes, intermediates, and general raw products that go to make up finished chemical products, and particularly dyes, may be used to manufacture explosives and toxic gases. We have, in a strong and vigorous chemical industry in peace, the means of national defense in war. Thinking of it in that light, should another country be allowed by a system of "kartels" to "dump" their supplies of dyes in our country and stifle competition, and drive our manufacturers out of business and our men out of jobs? The writer recognizes that the recently enacted tariff has afforded protection to the dye business, and that American manufacturers have that assurance that they may invest their capital in a vital industry and be permitted to develop that industry for what really is a national purpose.

1 Digest of Address given before the Joint Meeting of the Science Section of the New England Association of Colleges and Secondary Schools.

Is an industry that can attempt for a country to buy with one of its secret products immense areas of lost colonies an industry to be neglected? The following from the *Boston Transcript* shows the point in question, and whether the attempt is successful or not, indicates the power of the chemical industry and the wonders the chemists may aspire to.

TO BUY COLONIES WITH TAR.

German chemists claim to have evolved an aniline drug that will cure sleeping-sickness. Dream is that this may be used to restore African territory lost in war.

The German chemists are trying to win back the colonies that the German kaiser lost. They are offering to trade a new coal-tar drug for the African territory which Germany held before 1914, but which fell to the victors of the Great War. The territory amounts to a million square miles, or one-third the area of the United States, and has been divided up by mutual agreement among Great Britain, France, Belgium and Portugal. It comprises some of the richest and most fertile land on the globe, but it rests under a curse, the sleeping sickness.

This mysterious malady, that has laid waste a large part of the Dark Continent, is now known to be due to a minute parasite that lives in the blood of man and beast, and is called a trypanosome. When one looks at a parasite through a microscope, says Dr. Edwin E. Slosson of the Science Service, one would not think that so little a creature could have so long a name or do so much harm. He looks like a squashed mosquito wiggler or a stickless kite. He propels himself along by sculling with a whip-like tail. The tsetse-fly gets its living by sucking the blood of wild animals, cattle and human beings, and in so doing peddles about the microbe from sick to well.

There are various sorts of trypanosomes and blood-sucking flies, each having its own habits and routes, but anyhow, the infected individual suffers at first from fever and gradually sinks into an insensibility from which the sleeper rarely wakes. This sort of sleeping-sickness is peculiar to Africa and has nothing in common with the disease that has recently appeared in America, except the name and somnolent symptom.

In the latter part of the last century, when Europeans invaded the interior of Africa, they found the micro-organism the most dangerous of the wild animals to be combatted. Lions and elephants could be killed, but the tsetse-fly was too small to be shot and the trypanosome was too small to be seen. How to destroy the parasite without harming the host was the question.

CALL "TRYPAN RED."

The first sign of the solution of the problem came in 1904, when the German physician Ehrlich and his Japanese assistant, Shiga, discovered an aniline dye which, injected into the blood of a person seized with sleeping-sickness, would kill the parasite. This dye was named "trypan red." Two years later Mesnil and Nicolle, of the Pasteur Institute of Paris, found that several similar dyes made by the Bayer dye-drugs, were all derivatives of naptha-dye-drugs, were all derivatives of napthalene, familiar to us all, such as moth-balls are made from.

But none of the known dyes were sufficiently active so that they were certain to clean out the pests from the body of the patient. The Bayer company continued this search for something more powerful and equally innocuous, and has at last, after 204 compounds had been made and found unsaitsfactory, got one that cures, it is claimed. It is not a dye, but a white powder, soluble in water. It was tried successfully on mice, rats, guinea-pigs, rabbits, dogs and horses, and finally upon man. An English patient that has suffered from sleeping-sickness for a year and upon whom all the customary remedies had been tried in vain, was cured by four doses, amounting altogether to an eighth of an ounce. Better still, it is found that a single dose will make a person immune to the disease for a long period, even if infected by the fly. It is also said that the new medicine, or some of its relatives, will cure malaria and other tropical fevers.

FORMULA KEPT SECRET.

Whether Bayer 205 is a plain naphthalene derivative, like the earlier efforts of the firm, or whether it contains arsenic, like "606," which is used to destroy a similar blood parasite, is not known to the outside world, for the composition is kept secret. Small samples of the drug have been furnished for experimentation to Belgium, British and American physicians,

but under pledge of professional secrecy. At a recent meeting at Hamburg of the German Association of Tropical Medicine, one of the speakers said:

"Bayer 205 is the key to tropical Africa, and consequently the key to all the colonies. The German Government, therefore, must be required to safeguard this discovery for Germany. Its value is such that the privilege of a share in it granted to other nations must be made conditional upon the restoration to Germany of her colonial empire."

It is indeed the irony of fate that the Germans should have found the means of making their colonies colonizable only after they had lost them and that their discovery must go to benefit those who took their African territories from them. But this suggestion of buying back a million square miles for a single chemical symbol can hardly be taken seriously. The chemists of other countries are already hot on their trail, and with what clues they have will doubtless eventually find out the composition of the mysterious medicine. But whether Germany makes anything out of it or not, it may turn out that her scientists, by this discovery, will bring as much benefit to Africa as her soldiers did damage in Europe."

People say Germany is powerless, that all may relax because she has been disarmed. The writer had the privilege of hearing Clemenceau speak recently in Boston, and he says Germany has 500 officers in Russia training Russians in the manufacture of warlike articles. What would happen to little Poland, to say nothing of the menace to the rest of the world, if the Russian bear were harnessed and driven by the Prussian double-eagle? The information is authentic, as it was not only obtained by a reputable news agency, but verified by the intelligence department of the French Government. The following excerpt from the *Boston Transcript* outlines the proposition more fully.

"IS GERMANY PLANNING FOR WAR?

"The evidence collected by a correspondent of the London Daily Mail, to show that Germany is planning for a war of revenge, presumably against France, a summary of which is contained in an Associated Press dispatch of today, does not

in itself prove that 'Der Tag' will soon arrive; that the day will come when Germany will turn the table upon her chief opponent in the World War. The evidence, nevertheless, cannot be cast aside lightly, even by those who are convinced of the peaceful intentions of President Ebert's government. Germany, declares the Daily Mail's correspondent, has made arrangements to tap Russia's vast resources in the course of the war; she has established factories in Russia and is planning to build submarines and mine-layers in Russian dockyards; and to complete the necessary arrangements she has dispatched to Moscow some five hundred German officers. In Germany, moreover, says the Mail's informant, the military training of Germany's youth is quite general, and there are many unauthorized military organizations ready for instant expansion.

"These discoveries perhaps would not be so important if M. Clemenceau himself had not made virtually the same charges in the course of the recent American trip. Unlike the Daily Mail's correspondent, M. Clemenceau has obtained his information largely from the intelligence agents of the French Government. Yet the two channels of information parallel each other closely. The presence of smoke ordinarily indicates fire, and the rule probably applies to the case of Germany. The evidence points to the existence of a German military machine greater than that permitted under the terms of the treaty of Versailles; the evidence points also to a probable combination between Germany and Russia, which, if effected, might easily rule the continent of Europe.

"Under the circumstances, when there is a real possibility that she may be called upon to meet another German attack, it would be suicidal for France to demobilize her army, her army which is now her only assurance of peace. There is little need for American critics of France, whether in the United States Senate or outside that body, to criticise France for choosing the path of security rather than the path of danger. France has been invaded during the past fifteen hundred years on the average of once in fifty years. She has been invaded twice within the memory of some Frenchmen now living. Under present European conditions a strong army is her only defense against other German invasions, perhaps in the life of M. Clemenceau himself."

In view of all the above facts, do we need to be able to protect ourselves? Should we boost a chemical industry that makes us safe? The answer is obvious.

It puts too great a burden on our country to maintain in peace time a force to manufacture explosives, but if this force can be used for peace needs and still be available as a means of national defense, the difficulty would be solved.

In a pamphlet gotten out by the concern which is perhaps the largest manufacturer of explosives in the world, and with which the writer has been associated in the manufacture of explosives, dyestuffs, artificial leather, etc., appears, in part, the following:

"It should be understood that the equipment and the processes used in making such dyes are very similar to those used in making munitions. It is, therefore, proper to say that a dye plant is a potential munitions factory, and, as such, of the first importance to national defense. It takes years to perfect a dye plant; to have it ready means saving much precious time at the moment of national peril. Indeed, in the future it will come to having dye plants, or idle munitions factories, maintained at public expense, as the only alternatives by which security can be insured. A nation without a dye industry must have special plants in which to make explosives at a moment's notice. These will be a charge on a nation, but will be as essential as battleships, which are really only useful as a threat in time of peace. But idle munition plants are needless if the nation has flourishing dye plants, kept always efficient."

More important than plant or equipment are the trained men; those who can make dyes can make munitions, poison-gases, and everything else required. It does not take much study of formulas to make clear that manufacturing explosives is a very highly specialized industry. The specialist is not made overnight; he is the product of long training. From director to wage-earner, the dyestuff plant is in the hands of just those specialists who are needed for making the materials used in warfare.

That we succeeded in the conflict just passed was largely due to the fact that we had a reserve of trained men in those who taught chemistry in our institutions of learning. They

came forward and saved us from humiliation. We had those men and we had two years during which we learned how to make explosives before we needed to use them for ourselves. If the attack had been directly on us, much valuable time would of necessity have been lost while the college men were learning to handle materials on a large scale.

A permanent dye industry will mean a great stimulus to organic chemistry in the universities; it will allow of keeping more academic men engaged in research, and it is this research and it alone, which can keep us up-to-date enough to give us a chance in the adaptation of chemistry to war. Mustard-gas was first made in the university laboratory in the course of purely scientific investigation. These discoveries come of active investigation, they are a part of a growth in which we must share to keep our independence.

The Content of the Chemistry Laboratory Course

H. E. BROWN of W. M. Welch Scientific Company,
Chicago, Illinois.

THERE was published on pages 386-395 of "General Science Quarterly," of the January issue, 1922, an article written by Miss Ada Weckel, of the General Science Department of the High School at Oak Park, Illinois, entitled, "Are any Principles of Organization of General Science Evidenced by the Present Textbooks in the Subject?" and giving some very interesting data of the subject matter contained in the high school general science course. An effort was made to find similar information regarding the subject of Chemistry, but, as far as could be found, no such study had been made, and hence, in order to answer the questions in the writer's mind, it was necessary to make a study. The purpose of making this study was to determine what the average course in the chemistry laboratory is, as given in the modern high school textbook. This, it was reasoned, would give us a standard course in chemistry. It seems that these facts may be especially of interest to Catholic educators, inasmuch as the problem now

under consideration is the standardization of schools. The method of procedure was to select from the writer's library chemistry manuals that were found therein. Freak manuals were omitted. Only those manuals claiming to be suitable in a high school course in chemistry were included. Very old manuals were eliminated. Those included cover a period of time of a little more than the past ten years. There was found to be fourteen of these books, and it was thought to be a large enough number to be representative. The names of these books are listed below:

	NAME OF BOOK	AUTHOR
A.	"Laboratory Studies in Chemistry."	*Robert H. Bradbury*
B.	"Laboratory Exercises to Accompany Elementary Principles of Chemistry."	*Brownlee—Hancock—Fuller—Sohon—Whitsit*
C.	"Laboratory Exercises to Accompany First Principles of Chemistry."	*Brownlee—Hancock—Fuller—Sohon—Whitsit*
D.	"A Laboratory Outline of Elementary Chemistry."	*Alexander Smith*
E.	"Laboratory Exercises, arranged to Accompany First Course in Chemistry."	*McPherson and Henderson*
F.	"Exercises in Chemistry."	*McPherson and Henderson*
G.	"Laboratory Manual to Elementary Chemistry."	*Dennis and Clarke*
H.	"Elementary and Applied Chemistry."	*Irwin, Rivett and Tatlock*
J.	"Descriptive Chemistry."	*Lyman Newell*
K.	"Essentials of Chemistry."	*Hessler-Smith*
L.	"A Practical Chemistry for High School Students."	*Charles G. Cook*
M.	"Chemistry and Laboratory Manual."	*Morgan and Lyman*
O.	"General Chemistry."	*Lyman C. Newell*
P.	"Laboratory Study of Chemistry."	*Smith and Mess.*

The title and subject matter of each experiment in the text was recorded on a card. These cards were carefully sorted and arranged into groups, so that all experiments treating of one topic were included in one group, and it was found that there were thirty-seven different topics or groups, and these are listed below, and under each topic is summarized the material treated:

1. INTRODUCTORY LABORATORY PRACTICES NOT INVOLVING CHEMICAL KNOWLEDGE, including—Setting up Apparatus—Balances—Burettes—Bending Glass Rods—Capacity and Metric Systems—Density.
2. PHYSICAL AND CHEMICAL PROPERTIES AND PHYSICAL AND CHEMICAL CHANGES, including—Heating Metals and

Qualitative Weight Change—Compounds and Mixtures—Mixtures Changed to Compounds—Separation of Components.

3. THE STUDY OF WATER, including—Physical Properties—Chemical Properties—Boiling and Freezing—Filtration—Distillation—Electrolysis—Solubility in Water—Distribution of Water—Impurities in Water—Hydrogen Peroxide.
4. SOLUTIONS AND SOLUBILITIES, including—Solids, Liquids and Gases—Concentration by Titration—Solubility and Heat—Diffusion—Saturation and Supersaturation.
5. WATER OF CRYSTALIZATION, including—Deliquescence—Efflorescence.
6. PREPARATION AND PROPERTIES OF OXYGEN.
7. PER CENT OF OXYGEN IN THE AIR.
8. THE ACTION OF A METAL (SODIUM) ON WATER.
9. PREPARATION AND PROPERTIES OF HYDROGEN.
10. DEFINITE AND MULTIPLE PROPORTIONS, including—Burning Hydrogen in Oxygen—Equivalent of Magnesium, Sodium, etc.—Weight of a Liter of Oxygen—Atomic and Molecular Weights—Volumetric Composition of Steam—Making H_2O—Reduction of Copper Oxide by Hydrogen—Law of Definite and Multiple Proportions. In this group are included those experiments that are treated primarily so as to bring out the laws of definite and multiple proportions, and not to make a quantitative determination of an atomic weight.
11. PREPARATION AND PROPERTIES OF CHLORINE, including—Bleaching.
12. PREPARATION AND PROPERTIES OF HYDROCHLORIC ACID, including—**Tests for a Chloride.**
13. ACIDS, BASES AND SALTS, including—Neutralization—Double Decomposition—Acid Anhydridis—Hydroxides—Salts Ionization—Replacement—Hydrolysis—Acid Salts and Double Salts—Methods of Preparing Salts—Titration—Valence by Displacement—Colored Ions—Activity Series—Naming of Compounds.
14. PREPARATION AND PROPERTIES OF NITROGEN.

15. THE OXIDES OF NITROGEN, including—Preparation and Properties.
16. PREPARATION AND PROPERTIES OF NITRIC ACID, including—Aqua Regia—Nitrate—Nitrites.
17. PREPARATION AND PROPERTIES OF AMMONIA, including—Analysis of Household Ammonia—Compounds of Ammonium—Sources of Ammonia.
18. THE STUDY OF SULPHUR, including—Allotropic Forms—Preparation of Allotropic Forms—Sulphur Matches.
19. PREPARATION AND PROPERTIES OF HYDROGEN SULPHIDE, including Metallic Sulphides.
20. PREPARATION AND PPOPERTIES OF SULPHUR DIOXIDE, including—Sulphurous Acid—Detection in Foods.
21. PREPARATION AND PROPERTIES OF SULPHURIC ACID, including—Tests for Sulphates—Action with Organic Matter.
22. PREPARATION OF SUBSTANCES AND THE STUDY OF ELEMENTS AND COMPOUNDS, including—Properties of Special Substances—Processes, such as Cyanide process for Gold.

    Under this topic is included a great number of such experiments as "The Study of Chromium," "The Study of Tin," "The Ferrous and Ferric Characteristics," "Nitrogen Compounds as Fertilizers," etc. This list constitutes 349 of the total of 1422 experiments, or nearly 25% of the total, but may be recorded as the work which "acquaints the student better with chemistry but does not represent a part of the outline to develop the chemical theory," nor is it strictly qualitative.
23. BUILDING MATERIALS, including—Plaster Paris—Calcium Sulphate—Quicklime—Slaked Lime—Mortar—Cement.
24. PHOTOGRAPHY, including—Blue Prints—Silver Photography.
25. THE BLOWPIPE AND THE FLAME AND THEIR USES, including—The Bunsen Burner—The Candle Flame—Oxidation and Reduction—Kindling Temperature—Wire Gauze and Flames—Colored Fire—Davy Safety Lamps—Welsbach Burner—Flame Tests—Bead Tests—Borax Bead Tests—Cobalt Nitrate Tests.
26. CARBON, including—Wood Charcoal—Animal Charcoal—

Graphite—Coke—Deodorization and Decoloration—Carbon a Reducing Agent—Charcoal Filters—Allotropic Forms—Distribution—Destructive Distillation.

27. PREPARATION AND PROPERTIES OF CARBON MONOXIDE.
28. PREPARATION AND PROPERTIES OF CARBON DIOXIDE, including—Carbonic Acid—Respiration—Chemical Fire Extinguishers—CO_2 in Air and Breath—Oxidation—Combustion.
29. THE HYDROCARBON SERIES, including—Methane—Illuminating Gas—Acetylene—Coal Gas—Ethylene—Marsh Gas—Benzene—Preparation of Petroleum Products, Properties and By-Products.
30. WATER SOFTENING, including—Hard Waters—Calcium Oxide and Hydroxide.
31. STUDY OF FABRICS, DYEING, AND REMOVING OF STAINS, including—Fibers—Cleaning Fabrics—Acid Colors—Basic Colors—Mordants.
32. FOODS, including—Carbohydrates—Protein—Analysis of Flour—Analysis of Milk—Tests for Food Components—Fats—Vinegar—Butter—Oleomargarine—Dyes in Foods—Percent Water in Foods—Nitrogenous Foods—Albumen—Coagulation of Milk—Bread—Sugar in Vegetables.
33. PREPARATION AND PROPERTIES OF BAKING SODA, WASHING SODA, AND BAKING POWDERS, including—The Solvay Process—Sodium Carbonate—Decomposition by Heat—Tests for Carbonates—Calcium Carbonate—Acid Calcium Carbonate—Other Baking Powders.
34. PREPARATION AND PROPERTIES AND THE STUDY OF ORGANIC COMPOUNDS, including—Wood Alcohol—Fractional Distillation—Starches—Sugars — Fermentation — Ethyl Alcohol—Acetic Acid—Aldehyde—Ether—Esters—Glucose—Glycerine—Chloroform—Iodoform—Formaldehyde—Colloids—Preservatives—Soap—Miscellaneous.
35. QUALITATIVE SEPARATION, including—The Identification of Salts—Tests for Metals and Acid Ions—Separation of Groups.
36. QUANTITATIVE EXPERIMENTS, including—Copper in Copper Sulphate—Atomic Weight of Tin—Oxygen in $KClO_3$—Formula of Zinc Chloride—Analysis of a Silver Coin

—Composition of Zinc Oxide—Equivalent of Zinc—Per cent of Water of Crystallization in NH_4CrO_3—Percentage of Iron in Ferrous Sulphate—Percentage of Chlorine in Sodium Chloride—Atomic Weight of Sulphur—Percentage of Water in a Hydrated Salt—Equivalent of Aluminum—Percentage of Alcohol in a Liquid.

37. UNCLASSIFIED MISCELLANEOUS, including—Action of Hydrochloric Acid upon Oxides—Electrical Conductivity—Boyle's Law and the Barometer—Heat, Light, Electricity and Their Relation to Chemical Action—Thermometers—The Nascent State—Insecticides.

Each of the cards in each group was then examined to determine how many of the manuals treated of each of the different topics, and a list is given below showing the number of texts treating of the topics as they were found to group themselves. It will be noted that every text treats of thirteen of these thirty-five topics, and that thirty out of the thiry-seven are treated by more than ten text books and are on the average treated by thirteen out of fourteen text books. It seems, therefore, logical to conclude that thirteen out of fourteen texts, or about 93%, represent the fundamentals of Chemistry.

TABLE I.

Number and Name of Topic	No. of Texts treating this topic	No. of Exercises on topic in all books	Average No. of exercises per text	Weight
1. Introductory Laboratory Practices not involving Chemical Knowledge	9	18	2.0	1
2. Physical and Chemical Properties and Physical and Chemical Changes	14	43	3.0	2
3. The Study of Water	14	38	2.7	2
4. Solutions and Solubilities	12	34	2.8	2
5. Water of Crystallization	12	30	2.5	2
6. Preparation and Properties of Oxygen	14	31	2.2	1
7. Per cent of Oxygen in the Air	13	15	1.2	1
8. The Action of a Metal (Sodium) on Water	6	10	1.6	1
9. Preparation and Properties of Hydrogen	14	28	2.0	1
10. Definite and Multiple Proportions	13	39	3.0	2
11. Preparation and Properties of Chlorine, including Bleaching	14	31	2.2	1
12. Preparation and Properties of Hydrochloric Acid	13	24	1.8	1
13. Acids, Bases and Salts	14	90	6.4	3
14. Preparation and Properties of Nitrogen	11	13	1.1	1

15.	The Oxides of Nitrogen	13	26	2.0	1
16.	Preparation and Properties of Nitric Acid	14	38	2.7	2
17.	Preparation and Properties of Ammonia	14	30	2.1	1
18.	The Study of Sulphur	13	25	1.9	1
19.	Preparation and Properties of Hydrogen Sulphide	14	21	1.5	1
20.	Preparation and Properties of Sulphur Dioxide	13	19	1.4	1
21.	Preparation and Properties of Sulphuric Acid	12	19	1.6	1
22.	Preparation of Substances and the Study of Elements and Compounds	14	349	24.9	10
23.	Building Materials	4	8	2.0	1
24.	Photography	6	10	1.6	1
25.	The Blowpipe and the Flame and Their Uses	13	52	4.0	2
26.	Carbon	14	29	2.1	1
27.	Preparation and Properties of Carbon Monoxide	9	10	1.1	1
28.	Preparation and Properties of Carbon Dioxide	14	33	2.3	1
29.	Hydrocarbon Series	10	23	2.3	1
30.	Water Softening	9	11	1.2	1
31.	Study of Fabrics, Dyeing, and Removing of Stains	10	22	2.2	1
32.	Foods	12	38	3.2	2
33.	Preparation and Properties of Baking Soda, Washing Soda, and Baking Powders	11	31	2.8	2
34.	Preparation and Properties and the Study of Organic Compounds	14	95	6.8	3
35.	Qualitative Separation	13	51	3.9	2
36.	Quantitative Experiments	10	25	2.5	1
37.	Unclassified Miscellaneous	9	14	1.5	1
	Totals		1423		60

It will also be noted that in the table above there has been recorded in the second column the number of exercises in all of the text books. In the next column, to the right of this tabulation, is recorded the average number of exercises per text of the topic. If a little mathematics is applied and the total number of exercises in all of the texts on all of the topics be divided by the number of topics, we will find that, on the average, each text treats of each topic by giving it 2.5 exercises. Hence, we shall say that 2.5 is the average amount of consideration given to each topic. Therefore, in the next to the last column is recorded the average number of exercises per text. These texts which give 2.5 or less exercises per topic have been weighted as 1, and this is shown in the last column.

By adding these weights we find that it totals sixty. If we should choose as our laboratory course one with sixty experi-

ments they would necessarily treat of these different topics in proportion to these weight numbers. This means that there would be one exercise from topic 1, and two from topic 3, and hence we would have what would be considered the Content of the Average High School Course.

Topic 22, which contains a large number of experiments, was studied in detail so as to find what was treated most frequently by the various texts, in the same way as was determined for the entire chemistry course. It was thus determined which one of these sub-divisions of this group was most commonly treated. It was found that under topic 22, which studies the different substances and their formation and properties, these substances were treated most frequently: iron, aluminum, iodine, phosphorus, chromium, bromine, copper, lead, silver and arsenic.

The same examination was given topic 34, which was a Study of Various Organic Compounds, and it was determined which ones were most frequently treated. Starch and sugar, soap, and acetic acid were the three most frequently discussed topics. Hence, the table above gives a list of the exercises which represent the average course in chemistry and gives the number of exercises on each of the topics.

Summarizing, we may say that the content of the average, or perhaps ideal, Course in Chemical Laboratory work, as given by the average high school laboratory manual, treats of thirty-seven different topics, named in the above list, and that some of these topics are treated more than once, making a total of sixty exercises. It is not intended to infer that the chemistry course has reached the immobile stage where it is fixed, either incapable of change or undesirable that it be changed. Quite the contrary is true, and the contrary is necessary in order to have the greatest possibility for growth. A study of Table I will demonstrate in a very striking manner that there is a very definite agreement and a very uniform agreement of selection of subject matter of the authors of the modern chemistry laboratory manuals. Hence, it is quite possible to use this composite laboratory course in chemistry as a starting point for standardization, with a full realization that if this course be readily adhered to that one cannot be far wrong or far different from

the trend of modern education. Variations from this standard or this composite may be made, so as to provide special emphasis on phases of the chemistry course to meet certain specific or local needs.

The study of this subject matter of the high school chemistry laboratory text books is here presented with the hope that it may aid in the program of standardization by giving some more definite concrete ideas as to what may be considered as a standard or acceptable high school course. If, upon the basis of some such analysis, agreement could be made as to the standard for the chemistry course, as well as for the other courses, and upon this basis organized and standardized, then further development and improvement could easily be made from this as a starting point. It is evident, however, that some such analysis of facts is necessary before it would be at all feasible to attempt to agree upon what constitutes a standard course. Personal opinion is hardly a safe criterion, but the analysis of the present status of the present-day text books would offer a compromise basis.

A Brief Outline of Chemical History[1]

J. NORMAN TAYLOR, School of Graduate Studies,
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CHEMISTRY, as a science, is the youngest of the physical sciences, its birth-date being around the time of the French and American Revolutions. Its progress, therefore, may be said to have been the most rapid of any of the sciences. Students of chemistry, in order to appreciate its rapid development and to understand its present-day aspect, will recognize the value of giving a part of their time to a consideration of the historical literature of chemistry.

In the short time which we have at our disposal we can only outline the more important steps in the development of the science,[2] and briefly indicate our inestimable heritage from the workers who have gone before us.

1 A paper read before The Chemical Society of the George Washington University.

2 Dr. F. J. Moore's "History of Chemistry" deals with its development largely in a biographical manner. At the same time he brings out the fundamental ideas of the science. His book will excellently serve as a text for advanced students in chemistry and is admirably suited as a reference work for the use of Chemical Societies. Published by McGraw-Hill Book Company, Inc., New York, 1918.

THE CHEMISTRY OF THE ANCIENTS.

Thousands of years before the Christian era, chemistry was practiced as an art. This is evidenced by the monumental records of Egypt, as well as by the Biblical records and the writings of Herodotus and Pliny. Although the chemical arts are believed to have originated with the ancient Egyptians—and their temples are known to have had laboratories attached to them—China and India, in turn, have been regarded as the birthplace of the forerunner of operative chemistry.

ALCHEMY.

Operative chemistry had its origin in alchemy, and, as we have seen, it is impossible to say with certainty just when and where the art of alchemy originated. By some it is referred to the time of Tubal-cain, and the Byzantine ecclesiastics ascribed the "sacred art" to Hermes Mercurius Trismegistus. The expression "hermetically sealed," is evidently derived from his name. A study of the literature of alchemy by the "Alchemists" (a society in the University) leads to the belief that the language and symbols used convey more than an attempt at material transmutation and that they were esoteric tools for the teaching of lessons of religious import. Examination of the literature of alchemy indicates that its principles and tenets developed slowly and spasmodically. In the fourteenth, fifteenth and sixteenth centuries, the system attained a widespread favor, and, as in the ancient Egyptian temples, chemical laboratories were to be found in monasteries.

An important name in connection with the history of alchemy is that of Basil Valentine. He is supposed to have been a Benedictine monk who lived in Saxony the latter half of the fifteenth century; but little is known of him and there are grounds for the belief that the writings ascribed to him are the work of various hands.

IATRO-CHEMISTRY.

Many of the alchemists were practicing physicians, and as the number of chemical products increased, their value in therapeutics became more and more appreciated, giving rise in the fourteenth century to another school known as the iatro-chemists. They devoted their energies to a reform in the practice of medicine and to its closer association with chemistry. This

school of physicians attempted to show that life processes were essentially chemical and that abnormal conditions within the body could be corrected only by treatment with chemicals. The exponent of this idea was Paracelsus—Philippus Aureolus Theophrastus Paracelsus Bombastus von Hohenheim—a Swiss philosopher and physician. His many writings indicate that he used a large number of chemical preparations in his practice. The service which Paracelsus rendered to science consisted in bringing chemistry within the range of professional study. It was during this period that practical applications of chemistry were made in the industries: by Agricola in metallurgy, Pallissy in pottery, and Glauber in many technological processes. At the same time the common acids and the metallic oxides became ordinary commercial articles.

THE DAWN OF SCIENTIFIC CHEMISTRY.

If the intellectual development of Europe had previously been slow, particularly in science, the closing years of the seventeenth century were characterized by a spirit of scepticism and investigation. In 1661, Robert Boyle published "The Sceptical Chemist," challenging the idea of the Paracelsian elements and affirming the ideas of present-day chemistry. It was in this period that the "Invisible College" was formed and the foundation laid for the Royal Society.

PHLOGISTONISM.

The chemical theory known as the "phlogiston theory," and which dominated chemical thought for nearly a century, was proposed in 1660 by Stahl, and although radically wrong and even ludicrous, cannot be said to have seriously retarded the progress of chemistry. This theory was embraced by Becher, Scheele, Black, Priestly and Cavendish.

In the opening years of the eighteenth century, due to the labors chiefly of Boerhave, Geoffroy and Rouelle, there began to develop more definite ideas regarding chemical affinity, energy changes, and the relations existing between acids, bases and salts. During this century advances were made in analysis, its principles developed, and a system of identification set up by the work of Boyle, Hoffman, Marggraf, Scheele, Bergman, Gahn and Cronstedt. It was during this period that Cavendish laid the foundations for the further study of the gases, and chemistry was benefited through his researches in physics.

To the phlogiston period also belongs the work of Black on magnesium carbonate, the discovery by Scheele of chlorine, and the discovery by Priestley in 1774 of oxygen. This important event aided in the creation of what was styled as anti-phlogistic chemistry and whose chief supporters were Lavoisier and Berthollet.

Near the close of the eighteenth century, during the political cataclysm in France which nearly overwhelmed Europe, chemistry also experienced a revolution. Lavoisier was the leader of this Chemical Revolution, and although recognized throughout Europe as a distinguished philosopher and the dominating figure in the chemical world, nevertheless fell a victim to the insane fury of his own people. Through the discoveries and leadership of Lavoisier the phlogistic theory that heat and light are ponderable was banished, quantitative analysis was made possible, and the chemical equation brought into being.

THE ATOMIC THEORY.

The work of Lavoisier laid the foundation for further developments in quantitative analysis, but it was not until the discovery of the law of definite proportions by Proust and the subsequent enunciation by John Dalton, an English schoolmaster of the atomic theory, that the laws of chemical combination were understood. The acceptance of the Atomic Theory and the highly important and fundamental constants known as combining proportions, marks another epoch in chemical history. The way was paved for the work of Avogadro and Gay-Lussac and for the masterful work by Berzelius, the Swedish chemist, in determining so accurately the combining weights of the then-known elements.

If time allowed, we could take up in detail the invention of the voltaic pile, of its application by Nicholson and Carlisle to the electrolysis decomposition of water, and its application by Davy to the analysis of the alkalies and alkaline earths. But we can only at this meeting briefly call to mind some familiar names, such as Wollaston, Gay-Lussac and Thenard; and those classic workers in organic chemistry, such as Dobereiner, Liebig, Kekule, Wohler, Laurent and Thomas.

Our attention is especially called to the attempts about this time to classify the elements in such a manner as to show their

inter-relationship. That their properties had some connection with their atomic weights was noted by Proust, and "as early as 1829 Doebereiner called attention to the fact that there are certain triads of elements which show close analogies in their physical properties and certain regularities in their atomic weights." Pettenkofer, in 1850, and Dumas, in 1852, elaborated these previous conceptions, and in 1854 Dr. Josiah P. Cooke, of Harvard College, "made a classification more elaborate and complete than any which had preceded it." Later, Newlands, an English scientist, brought out his "law of octaves," but the evolvement of a more thorough generalization remained for Mendelejeff and for Lothar Meyer to formulate. These two men arrived simultaneously and independently at the same conclusion which is expressed in our modern statement of the periodic law, that "the properties of the elements are periodic functions of their atomic weights."

The rise of physical chemistry would be interesting to trace, but time does not permit, and we can only mention the names of some of its pioneers, such as Boyle, Black, Cavendish, Lavoisier, Faraday, Dulong and Petit, and Bunsen. The law of mass action, given form by Guldberg and Waage, the phase rule of Gibbs, the researches of Hittorf, Kohlrausch and others, bring us to the present-day scientists in the field of physical chemistry.

An evening could be spent in reviewing the history of radiochemistry and subatomic phenomena, but time forbids, and we can only, in passing, call to mind the work of Crookes, Thomson, Rutherford, Soddy, Becquerel and the Curies.

History is in the making day by day. The advances made in chemistry during the World War are gradually being brought to light. And we, as students and teachers of chemistry, may well study the lives of the men who have in the past so largely contributed to its progress. But let us too, learn from our illustrious contemporaries: Arrhenius, the propounder of the theory of electrolytic dissociation; our own Munroe, the inventor of smokeless powder; Baekeland, the technologist; Chandler, Clarke, Johnson, Lewis, Langmuir, McNeil, Morgan, Noyes, Power, Remsen, Smith, and scores of others who are actively engaged in research, teaching and administration. A study of their lives and their works and writings will inspire us to achievement.

Three Miles a Minute

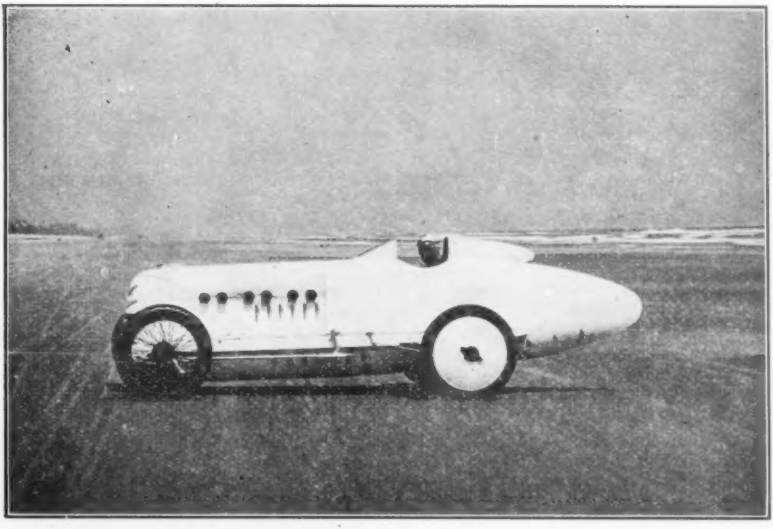
On April 7th, 1922, at the world's greatest speedway, Daytona Beach, Florida, Sig Haugdahl in his Wisconsin Special broke all world's record for one mile. His time was 19.97 seconds or an average of 180.27 miles per hour. He also established records of one kilometer, 13.91 seconds; five miles, 1 minute 56.02 seconds, and ten miles, 3 minutes 56 seconds. These records mark a new epoch in the chronicles of speed, for never before has man travelled at the rate of 3 miles per minute.

Parkersburg-Ohio Bridge

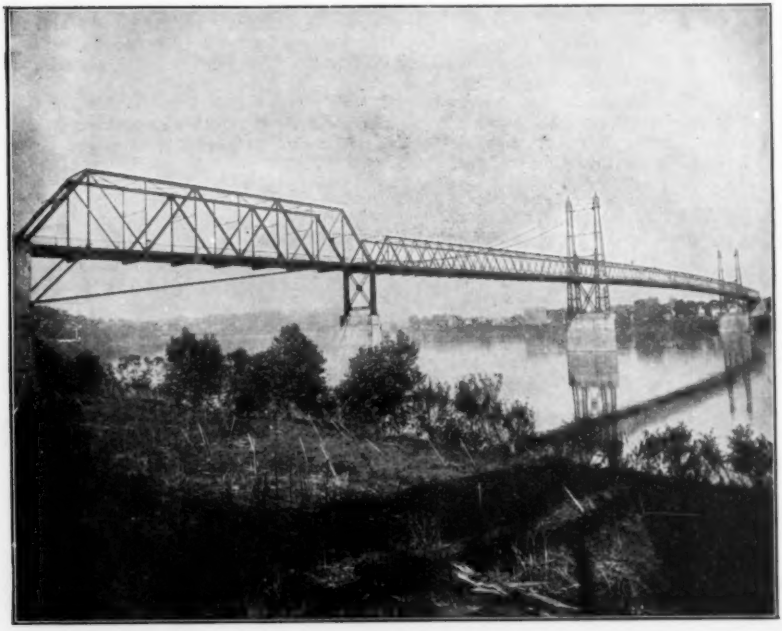
The illustration (p. 217) shows the bridge over the Ohio River owned by the Parkersburg-Ohio Bridge Company, Parkersburg, W. Va. It is painted with Dixon's Silica-Graphite Paint. The bridge is operated by the Parkersburg-Ohio Bridge Company, of which Mr. H. P. Camden is President. We quote from Mr. Camden's description:

The bridge is 2,800 feet long and is a combination of steel truss and suspension type. The main span is 775 feet long. Hermann Laub, Bridge Engineer of Pittsburgh, was the designer, Laub & Stuart, contractors. The American Bridge Company fabricated the steel work. The value of the structure today is about $1,000,000.00. The building of this bridge was inspired by the Board of Commerce of the City of Parkersburg, and the construction of it was financed by the District of Parkersburg and by private subscription on the part of certain citizens of Belpre, Ohio. The beautiful Ohio River at this point has witnessed notable history in discovery. Revolutionary and Civil War days, and not very far away General Grant was born on its shores."

—From "Graphite," by courtesy Dixon Graphite Co.



The car that made 3 miles a minute.



Parkersburg-Ohio Bridge.

Book Reviews

Letters of a Radio Engineer to His Son—John Mills—256 pages—136 figures and 12 plates—$2.00—Harcourt, Brace and Co., N. Y.

The first two chapters of this book take one through the fascinating story of the relation of protons and electrons in the atom. The third chapter tells in true scientific terms "how a battery works." This is all done in popular language for the layman and in such simple language and with such clear illustrations that your youngest students can understand. The pleasing style is as free and easy as might be expected in a series of letters and yet all the intricacies of radio are fully explained. Anyone who masters this book should be well qualified for the title "radio engineer." Besides purely radio discussions the reader will absorb a large amount of general science information on a variety of subjects. We recommend this book not only for every general science library but for all pupils who are really interested in radio and who wish to understand the science involved in it.

Automotive Manual—A. L. Taylor and A. H. Blake—178 pages—63 illustrations—The Macmillan Company.

This is a manual of 34 exercises for the laboratory and repair shop. Each exercise has three parts: (1) an introduction, giving explanations and theoretical considerations; (2) detailed directions for shop work; and (3) a series of questions covering the subject both from the theoretical and the practical standpoint.

Some of the exercises are: the four-stroke cycle engine, carbon remover, valve grinding, valve timing, bearings, tearing down and assembling carburetion, cooling, lubrication, batteries, ignition, starting and lighting systems, clutches, transmission, differential, wheels, springs, brakes and winter care.

It is a book for the owner of a car who wishes to do his own repairing, as well as for one who makes automotive repairing his business. The course will be of great value to students who are or will be automobile owners.

Laboratory Manual in General Science—Frederick C. Mabee, Zee Tsoh Wu and Li Ging Biao—102 pages—illustrations of apparatus—published by authors at Shanghai College, China.

General Science has made a good start in China, and the first laboratory manual in the Chinese language appears in this book. This manual has been prepared for the middle schools, and is made up of problems and projects in general science. Eight pages—preface and suggestions to teachers—are printed in English, the remainder of the manual giving specific directions to the pupil for carrying out his experiments or projects is in Chinese.

Physics for Secondary Schools—Frederick E. Sears—658 pages—523 illustrations—F. M. Ambrose and Company.

Physics for Secondary Schools is a strong book, especially in the stress given to physical principles and mathematical treatment. It has a goodly number of practical applications, and the historical treatment is excellent. There is a chapter on radio, and a good account of the electron theory. The book is one you can safely use in classes in which a number of pupils are preparing for college entrance examinations.

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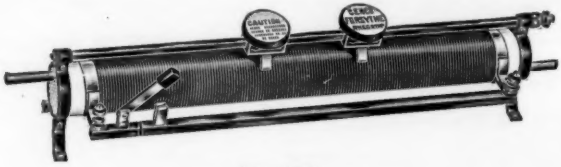

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BORAX

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BOTULISM

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The microscopy of food. Ill. L. A. Hausman. Sci. Amer., 127: 256.

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Planting fruit trees for beauty. Clarence Fowler. Gar. Mag., 36:102. Oct. 1922.

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The game of health in Minneapolis schools. M. Juell. Nation's Health, 4:621. Oct. 1922.
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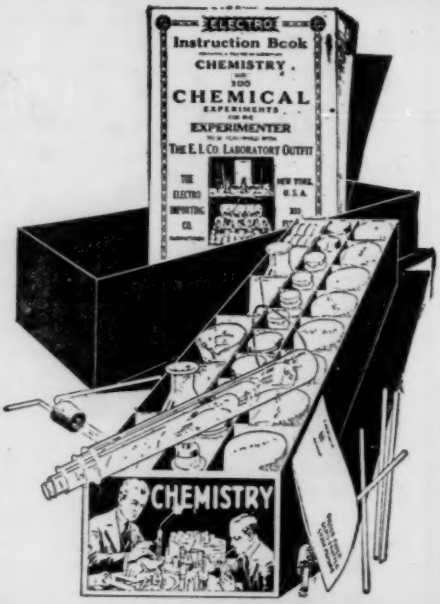

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The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Illustrated World. Drexel Ave. and 58th St., Chicago. Monthly. 25c a copy, $3.00 a year. Many short articles on applications of science and mechanics. Popular in style and attractive to elementary and high school pupils.

Industrial Education Magazine. Peoria, Illinois. Monthly. $1.50 a year, 25c a copy. An illustrated magazine, which is indispensable to the shop instructor and to others who would "keep up" in industrial education.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

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